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The Engineering Side of Illumination.

During recent years there has been a growing realization among engineers that one of the greatest needs of modern illumination is a more scientific treatment of its commercial problems. Artificial light plays an important part in most classes of industrial work, and its efficient application is a greater influence in intensive production than many people imagine. The drafting room and the shop are both handicapped by misapplied illumination and the cost of turning out a particular job may be increased several per cent. by a poor arrangement of the lighting equipment. If the installation does not enable the force to produce work under conditions as nearly as possible equal to daylight, inefficiency and delays are almost certain to creep in.

Wasted light means needlessly heavy bills for electricity or gas, amounting to a good many hundred dollars a year in the case of a large organization, but the influence of bad lighting on production is still more important. This was emphasized in a recent issue of the "Illuminating Engineer," which showed that decrease in efficiency of the workman by poor illumination represents a far greater loss than even the most wasteful methods of producing and using the light. At 10 cents per kilowatt-hour for electric current, which may be taken as a maximum in the case of a large installation, the ordinary 16-c.-p. lamp costs about half a cent an hour, which is but 1 per cent. of the value of the workman's time, assuming the latter receives 50 cents an hour. In other words, if the workman loses six minutes during the day on account of poor illumination, the money value of the time will equal the cost of a lamp sufficient, in most instances, for all the special light he would require in a ten-hour day. In cases where electricity is generated on the premises under economical conditions, the workman may have to lose only about one minute of his time during a ten-hour day to equal the daily cost of a 16-c.-p. lamp.

The engineering side of illumination concerns itself primarily with making the best possible use of the means at hand. It is unfortunate that the accurate measurement of lighted areas is at present in such an undeveloped stage, although in the hands of a careful observer the modern illuminator yields results that check within about 10 per cent. The construction and maintenance of standards of light are matters falling within the province of the physical laboratory; to most engineers the issue is the proper application of the lighting units, shades, reflectors, globes and fixtures already on the market. The desirability of better equipment is no excuse for the failure to conserve the light which is being purchased, whether the application be an installation of arc lamps by a contractor to push night excavation or the use of translucent bulbs in the berth of a sleeping car. Economy lies on the side of concentrating the light where it is needed, instead of squandering it all over the premises. The proper use of reflectors on an excavation job may be a positive factor in the reduction of labor costs.

In the selection of lamps for a given service, many points besides efficiency need to be borne in mind. The tantalum lamp of 2 watts per candle may be well suited to the quiet of the drafting room, where direct current is available, but it makes a poor showing on alternating current or when subjected to vibration. Even the 2.5-watt metallized filament lamp has not driven the thick filament 4-watt carbon incandescent lamp from its place on the trolley car. It is just as important for the engineer to analyze first cost, guarantees of delivery in quantity on short notice, efficiency, life records, reliability and quality of output in specifying lamps as in selecting motors, for the lamp frequently comes in closer contact with the operating force of the shop or plant, except in direct-driven installations. Quantitative measurements are absolutely essential in studying these problems. Even approximate data, such as are secured by measuring the average number of square feet of floor area per rated candle-power in similar installations, or gained by employing the illuminometer with discrimination, or by comparing the relative legibility of various sizes of type held at a known distance from the same observer's eyes, serve a more reasonable purpose than haphazard guesswork as to the amount and quality of a given illumination. The physical laboratory's latest progress in the study of illuminants may any day have a direct bearing upon the commercial work of the engineer, but admiration for the achievements of the scientific investigator of artificial light should not blind the consumer to treating the illumination problem with the same common sense which he gives to any other engineering question, fortified when necessary by expert advice.

Movable Bridges.

The innumerable intersections of railways and highways with navigable streams in this country have made imperative the evolution of movable bridges as a class of structures essentially distinct from the ordinary bridge, although involving many of the fundamental principles of their design. At the present time the movable bridge has reached such a position of importance in metallic structures as to require practically independent treatment in the requisite specifications, both as a structure and as a machine. It may be called the only dynamic structure in the civil engineer's practice. While he deals with machinery and machines in almost endless variety, the movable bridge is practically the only structure which he builds for motion as well as for a fixed position.

Although some forms of movable bridges are almost or quite as old as history, the modern movable bridge is of recent growth. There are many engineers still living in the active practice of the profession who literally struggled with the rational design of some of the earlier swing bridges carried on rim-bearing turntables. With the scanty analytic knowledge forming the basis of accurate design in those days, the results of such struggles were not always in the highest degree successful, although in the main they were surprisingly satisfactory. The same observation is equally true of the first examples of the center-bearing draw span which has now attained such an eminently satisfactory character for some of the longest structures.

The importance of this class of bridges has never been more clearly and pointedly set forth than in the paper on "Movable Bridges," by Mr. C. C. Schneider, in the "Proceedings" of the American Society of Civil Engineers for February. While much has been written on this general subject, it has probably never been more comprehensively and concisely treated than in this paper. Mr. Schneider's extended experience in the design and construction of practically every type of these structures now in use in the United States gives the paper exceptional value, especially that part of it devoted to specifications. The salient features of the older forms of the rim and center-bearing bridges, with their merits and demerits, are well set forth, no less than the corresponding features of the modern bascule type with its variants. For many years the rim-bearing table was so generally used for the heavier swing spans that it came to be standard, to the exclusion of the center-bearing table which was regarded as peculiarly adapted to light spans. It is probably not much in error to state that later the wide extension of the simpler center-bearing table to long and heavy swing spans was due largely, if not chiefly, to Mr. Schneider's own practice, until at the present time its merits for simplicity and definition of stress computation, ease of turning, less liability to get out of order and other merits, are clearly recognized.

The general principles laid down by Mr. Schneider for the selection of a design, that each arm of the bridge when closed shall be as nearly as possible an ordinary span, with simplicity and efficiency of operation of the machinery separate and distinct from the structure of the bridge, are probably concurred in by every engineer of experience. So far as these principles are applicable to the rim-bearing turntable it is a matter of no little interest to observe that the condition of "partial continuity," which has been so widely used, is in complete harmony with them. This condition found its first application more than thirty years ago in the design of some of the earliest successful long-span swing bridges, and the marked advantages attaching to it have maintained it in practical use for the rim-bearing turntable ever since. Its employment eliminates much of the indetermination which would exist with complete continuity. Those engineers who have had to re-establish the center castings of rim-bearing turntables after they have been pulled out of place by imperfect track structure and maladjusted rollers will subscribe most heartily to Mr. Schneider's criticisms, in this respect, on what may be called the sub-structure of that class of tables. In fact, many of the older center castings were so indifferently anchored to the masonry that they frequently had to be re-established by a much heavier anchorage than was at first considered necessary.

The bascule type of movable bridge is more recent in its development, in spite of the great age of the type, than those carried by the rim and center-bearing tables. It has many advantages for certain conditions and has already been brought to a high degree of excellence. It occupies much less space for its motion and is peculiarly adapted to a multiplicity of tracks. The ease and comparative economy with which the requisite machinery can now be manufactured and installed makes the construction and maintenance of this type of structure expeditious and economical. A number of types possess efficiency of a high order, especially in view of the reduction of friction in the best classes of heavy trunnion bearings when the rolling form is not used.

The power required to operate movable bridges is more or less an uncertain factor, in consequence of the wind resistance being the greatest which has to be overcome and the excessive variation in its amount. The frictional resistances of the motor and of transmitting machinery as well as the operating parts of the moving structure, can be provided for with reasonable certainty and are relatively small, but the amount of wind resistance to be overcome in the case of a long swing bridge is comparatively great and exceedingly variable. In the earlier bridges, naturally, the power required was much underestimated, but with the accumulation of experience the power of the motor can be more nearly assigned, although at the present time, even, the only rule seems to be to provide abundantly and then expect at times to experience some shortage. On the whole, Mr. Schneider's paper is one of unusual interest and covers admirably a class of structures whose rational design has necessarily been subject to slow development.

The Power Supply Situation in London.

One of the important subjects which will come before Parliament this year is the tangled situation regarding the supply of electricity throughout Greater London. At the present time there are over sixty stations for lighting alone in the metropolis. Some are owned by companies and others by local authorities. It is understood that some of them are fairly good plants, and it is well known that others are of interest solely from a historical standpoint or as junk. All kinds of apparatus can be found in them, and the current is distributed in an equally great diversity of ways. As a result, the cost of electricity for power purposes is very high, so high that manufacturers have complained bitterly about it and some of them have even used it, along with high taxes, as an explanation of the reason for the removal of their shops to other places. Parliament has been alive to the situation, but has not yet been able to do much to remedy it on account of the various complications introduced by the people interested in existing stations and by the municipal ownership proclivities of the last London County Council. Since the taxpayers at the recent election decided so plainly against the burden of any further municipal ownership ventures, it is probable that the latter aspect of the problem will not require serious consideration for the present, and the work to be done first is to determine what is the best method of furnishing this great community with current.

Three bills have been introduced which furnish an interesting subject of study. The first is what is known as the London electricity supply bill, which has been offered by the thirteen companies now in existence. It proposes to relieve the situation by abolishing certain restrictions under which these corporations now carry on their business. In order to maintain competition, provisions were inserted in their charters prohibiting them from associating with each other. They now ask permission to supply current to each other and to amalgamate their undertakings. The former request is one which seems entirely fair and likely to result in benefit to the consumer, but any consolidation of companies is naturally looked upon with suspicion. The second project is outlined in the London County Council bill, which proposes to establish two great public central stations from which current will be supplied in bulk to the existing small stations for distribution. It is estimated that the capital cost of such large stations will be only one-fifth of the cost per kilowatt of the present plants and their operating expenses will be correspondingly low. This project is approved by a good many people, who look with much disfavor on the accompanying proposal to have the County Council purchase all the existing lighting plants at a cost of about $90,000,000. This latter scheme will probably be abandoned by the new Council and the bill will be simply one for supplying current in bulk to existing stations. The third proposal is embodied in the bill of the Administrative Power Co., which almost became a law in 1905, in a somewhat different form. As now drawn, it gives the Council authority to turn over to a private company whatever powers it possesses regarding electricity supply, keeping such control over the business as it may arrange with the company. This project is one suggested as a practicable solution of the matter by a Parliamentary committee which reported on the situation last year. The general plan of the company was considered by the committee to "be conceived on scientific lines and calculated to afford a cheap supply of electrical energy at private risk."

The problem presented by these three bills is one of the most interesting now afforded in large cities, for it brings directly into debate the subject of the relative advantages of public and private management of such an important public service as the supply of electric current. If London had not had such an overdose of poorly managed municipal trading, it is possible that the debate would not be so one-sided as it promises to be. The feeling of the people, as expressed at the last election, seems to be that nothing more shall be undertaken at public expense which private capital will assume. Consequently it is possible that the real issue will lie between the first and the third of the projects mentioned. Even if this should prove to be the case, it will be possible to go deeply into the vital subject of the degree of control which a public body should exercise over a corporation doing business under powers delegated to it by that body. This question is now becoming vitally important in a number of countries, and it is for this reason that the future proceedings respecting the London power bills deserve special attention.

Road Improvements in Illinois.

The first annual report of the Illinois Highway Commission is a document deserving study by those interested in road improvements. It is one of the most gratifying indications of progress toward good highways that has been received in some time. Illinois long had the reputation of being in places almost impassable at certain seasons of the year. People marooned in some sections when the spring thaw was taking place remained fixed, according to report, until the season had advanced sufficiently to allow them to escape from the mud. Although the condition was bad, nevertheless a good deal of money was regularly spent on country roads and bridges. In 1905 it was over four and a half million dollars, considerably more than fifty dollars per mile of road. This large sum was spent by people without any real knowledge of the subject, as a rule, and with no experience in the construction of good roads. Naturally a large proportion of it was wasted, and one of the good things which the Illinois Highway Commission will accomplish is the prevention of most or all of this waste in the future. The necessity of some oversight of the expenditure of such large sums is enhanced by the fact that the expenditure for roads and bridges is increasing quite rapidly, and there is every indication that such an increase will continue. Naturally, this must be the case, for with the growing population of the State the need for better roads and bridges is also increasing.

The good road problem in Illinois has long been complicated by the fact that there is very little material suitable for improved highways to be found in a good many parts of the State. Even assuming that there was plenty of good stone available for such roads, it is contended by some people that the soil of the corn belt portion of the State is so sticky that it will pull to pieces any broken stone roads that can be constructed. Few things are so destructive to a good road as the mud which is pulled over the surface from intersecting dirt roads during the wet season. It is interesting to observe that even the Highway Commission and its engineer, Mr. A. N. Johnston, who has had much experience in highway construction in other parts of the country, are at a loss as to just what measure of success can be attained with such roads in some portions of the State. In order to settle this the Commission has decided to build five pieces of experimental road. It is much better to spend a moderate sum for such experimental construction than it is to place a large mileage of highways under construction only to find that the methods were imperfect and most of the money spent has been wasted. Few people who are not aware of the scarcity of rock, the difficulties of drainage and other road troubles in some portions of Illinois, can appreciate the impracticability of knowing what improved highway work in portions of that State really involves. It is even impossible to tell what will be the cost of macadam and telford roads in portions of this State. Some people have claimed that the cost would not be more than $1,500 per mile, and others have claimed that it would be at least $10,000. Accordingly, the Highway Commission has kept a very close detailed record of the cost of the experimental roads it has built, and it is believed that this information will be of considerable value in ascertaining the cost of more extensive work in the future. It is gratifying to observe that a number of communities recognize the importance of such preliminary investigations and experiments, and have co-operated with the Commission in constructing several miles of road under conditions which are practically equivalent to those of work done by the Commission itself, so far as yielding useful data is concerned.

One feature of the highway work in the State which deserves careful consideration is the construction of bridges. At the present time, probably nearly one-half of the total annual appropriations made by the various communities for road work are spent on bridges alone, a considerable portion of it for new structures. Probably a large part of the money is wasted. The method of securing contracts for steel bridges in rural districts is generally notoriously bad. In order to prevent wasting money on inferior structures the Commission has offered the services of its engineer gratuitously to road officials, for it believes that by so doing it can materially increase the standard of bridge work and at the same time decrease the cost to a material degree. The Commission reports that there is a strong desire on the part of road districts in many parts of the State to secure competent advice regarding the plans and construction of bridges, but unfortunately the authorities do not always seem able to go about securing such help in a proper manner. The Commission very properly points out that it would be advisable for the State to give some authority the power to approve all plans for bridges over a certain length of span and costing more than a certain sum. The numerous failures of such structures, particularly during the season when road rollers and traction engines run about the country, emphasizes the desirability of some such law.

In view of the fact that the Commission was not organized until February, 1906, the members of that body have every reason to feel proud of the work accomplished since that date. It is impossible to make progress in any undertaking like the improvement of the roads of a State without knowing at the outset, before plans are prepared in any great detail, just what are the local necessities, possibilities and resources. In laying out a wide-reaching system of road work it is very desirable to know the amount of travel on different routes and parts of routes. Probably travel statistics have never before been collected with such completeness as is now being done in Illinois by the Highway Commission. The method followed was described a few weeks ago in this journal in a paper by Mr. Johnston. If data of this nature were collected more often before projecting important highway improvements, it is probable that considerable money would be saved which is now spent in building improved roads in places where the traffic over them is probably not more than half a dozen or a dozen teams each way daily. Along with the information concerning the present amount of travel on different roads, the Commission has been collecting information regarding the construction of earth roads and their present condition. This is a particularly important subject in Illinois, for the reason that most roads in the State are ordinary dirt roads and must continue to be such for a good many years to come. Fortunately they can usually be very materially improved, and one of the first bulletins issued by the Commission was on the subject of such improvements. In various parts of the State roads have already been built of macadam, gravel, brick and other materials, and all available information regarding such construction is being collected and compiled for future use. Data of this nature are frequently of material service in the discussion of various improvements. It is manifestly much better to collect it now than after improvements have been authorized which might never have been placed under construction had more information concerning the cost of the work been available. The scarcity of material for good roads in the State has also led the Commission to make studies, so far as its means enabled it to do so, of the available materials within the limits of the State. It has also looked into the matter of crushing stone in the State penitentiaries, and it has interested the railroads in road work to the extent of securing from them special rates for hauling crushed stone for use on public highways.

Before the Commission was organized there was a pretty general feeling that good roads were not desired in most parts of Illinois. It was asserted many times that the farmers of the State, particularly those in the corn belt, had other uses for their money. It was held by some critics that there really was very little need for improved highways in parts of the State devoted to farming, because, through long custom, the farmers had learned to carry on their work in such a way that there was plenty for them to do at home during those seasons when the roads were impassable. The experience of the Commission during its first year indicates that all such criticism failed completely to estimate the true feeling of the people in the rural districts regarding improved highways. There is a much larger demand, the Commission states, for information concerning good road and bridge building and a much greater desire to utilize this information than any one could have anticipated. The act under which the Commission carries on its work does not provide for any State aid in road construction, but merely makes the Commission a sort of consulting body which furnishes information to road officials when they so desire, and also gives it authority to carry on investigations and experiments which will furnish information concerning the best manner of building roads and bridges in the State. Although there is nothing in the report of the Commission which indicates that out of this preliminary work will come a State aid law, nevertheless, those who take the trouble to examine carefully what is now being done in a preliminary way by the Commission, will be convinced that the people of the State will soon demand some form of State aid in building roads, and that a great move toward such construction will result.

Engineering Opportunities in Public-Service Work.

A few weeks ago mention was made in this journal of an interesting series of letters in the "Electrical World" on the opportunities for technical graduates in central station work. Since the publication of that article a belated contribution to the discussion has been made by Mr. Henry L. Doherty, who probably employs more technical graduates in central station work than any other person in the country. His close connection with many lighting corporations makes his opinion of the opportunities among them for the graduates of technical colleges a decidedly instructive one; this is particularly so because he has a high appreciation of the work being done by such schools, and his remarks apply fairly closely to other classes of public service operations and to general business enterprises, outside of those directly connected with manufacturing. In his opinion the problems which confront a central station to-day, and consequently the classes of work for the staff, are grouped in the following divisions: The first is the protection of the investments by proper handling of corporate matters and the policy of the company towards the public. The second is the development and enlarging of the market. The third is the production of current from the coal pile. The fourth is electrical engineering in so far as it relates to the design of electrical apparatus. In other words, Mr. Doherty's experience has been that it is more difficult to secure men able to look after the company's corporate matters and direct its policy than to secure any other class of assistants. The class least difficult to obtain is the electrical engineer able to design the details of an electrical installation.

It may surprise a good many people to learn that the design of electrical apparatus is the least important feature of central station work at the present time, but it needs only a little consideration to become convinced that this is the case, for practically all such work is now done in the large engineering manufacturing establishments. Formerly, when small machines were used and all machinery was driven by belt, the designing engineer played a much more important part than at present. At the present time apparatus is better built, is of more uniform behavior, requires less special knowledge and is less complicated and more easily understood, both by technical graduates and ordinary laymen, than before. In consequence it is really much easier in some respects to operate a large station to-day than it was fifteen years ago. This being the case it is somewhat surprising to learn that no less than twenty graduate engineers were put on the pay roll last year in a single one of the central station companies under the direction of Mr. Doherty. In the Denver company alone there are now over fifty graduates of technical schools employed, which is conclusive proof of the feeling with which such men are regarded. In the various industrial plants with which he is connected it would be hard to say, Mr. Doherty states, whether the practical man had benefited most by association with the technical graduate or whether the latter had profited most by mingling with the practical men. Probably the practical men had the better of the bargain. They have secured more efficiency from the knowledge gained from the technical graduate than the latter has secured from what he has learned from the practical men. As Mr. Doherty well points out, men become practical if they have to do things, but technical education is not so easily acquired from necessity.

Unfortunately there is nothing in the communication by Mr. Doherty to the "Electrical World" which indicates just what he considers the best field for technical graduates in central station work. He points out that it is possible for a man who can develop additional business of the right sort to reduce the total cost of current on a unit basis more than it is practicable for the engineer to do. By total cost is meant not merely the expenses of operation, but all costs, both fixed and operating. This being the case, he believes that proper credit is not often given to the man who develops new business. On the other hand, he sees no reason why the engineer cannot be made a better man for developing such business than somebody without a good knowledge of central station work. Apparently, therefore, the opportunities for advance which such central station engagements afford are largely those of a business nature, which is equivalent to opinions expressed by other employers of large numbers of high-grade men in semi-public works. This does not mean, however, that the graduates' education of a technical character has been wasted. A good education, backed up by proper training, represents a particularly desirable form of capital, equivalent in some cases to half a million dollars. Like all other capital, however, it must be invested judiciously, and the great lesson which engineers can learn from Mr. Doherty's experience is that it is better to accept a fair rate of interest on this capital and keep it intact, rather than to squander it for the sake of a high rate of interest for a short time only. The great positions in engineering circles are mainly in connection with large corporations, and to secure these positions it is necessary to build up a reputation which cannot possibly be secured if a person jumps from one engagement to another whenever there is chance of obtaining a small additional salary per month. An important statement in Mr. Doherty's article is that in his companies they like to have the men view their work from the standpoint of what they would do if they owned the property, or if they were the chief executive officer. Nobody can have this viewpoint who keeps his mind fixed mainly on his salary instead of on his work.

Looking North over Southern Half of the Pipe Gallery.

THE CINCINNATI WATER PURIFICATION PLANT.

By E. G. Manahan, assistant engineer, and J. W. Ellms, chemist, of the Engineering Department of the Board of Trustees, "Commissioners of Water Works," Cincinnati, Ohio.

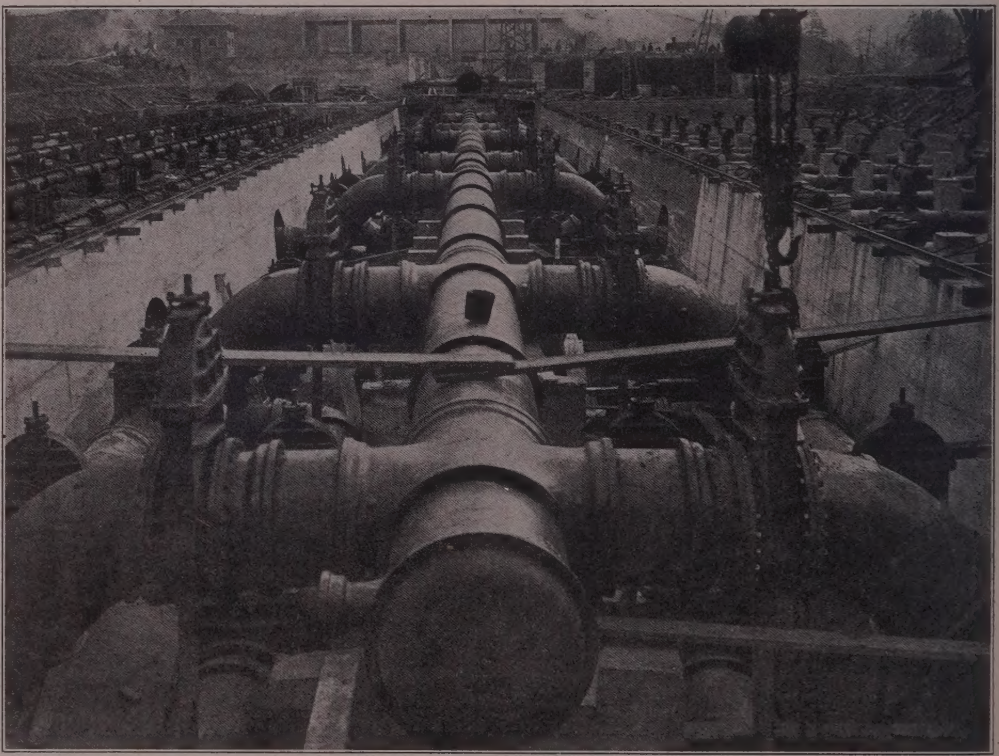
The City of Cincinnati has always obtained its supply of water for municipal purposes from the Ohio River. The large amount of sediment carried by the river water renders it unsightly and unpalatable for domestic use. The waterworks intake of the old plant has been in continuous use since 1821. It is located at a point which now is over four miles downstream from the eastern limits of the city. The Kentucky shore is also closely populated for almost an equal distance above the intake. In consequence the river water is much polluted by sewage and, without purification, is unfit for drinking purposes.

The quality of the water supply has been the subject of discussion for many years. As the city increased in size the pollution of the water in the vicinity of the intake became more pronounced. In 1865 James P. Kirkwood was retained by the city to formulate plans for the extension of the works and the improvement of the water. His plan contemplated the removal of the intake upstream to a point above the settled portion of the city, and the construction of settling reservoirs and filters. The estimated cost of the proposed plant was over $3,000,000. The plan, although at first favorably received, was finally rejected.

For thirty years following the rejection of this plan the question of an enlarged and improved plant and a purer water supply was periodically agitated. But little was done until an Engineer Commission was appointed in 1895. The three expert engineers appointed were Messrs. John W. Hill, Samuel Whinery and George H. Benzenberg. They were directed to make the necessary investigations, draw up plans and prepare estimates of cost for the extension and improvement of the waterworks plant. In their report they recommended the construction of a new intake about ten miles above the city in order to obtain a supply free from local sewage pollution. They submitted plans for new pumping stations, settling reservoirs, filter beds, clear water well and high level distributing reservoirs, with the necessary pipe lines for connecting the various parts of the plant and for delivering water into the city. The estimated cost of the new plant, which was to have a daily pumping capacity of 80 million gallons and a filtering capacity of 66 million gallons, was approximately $6,500,000.

As a result of the agitation at this time, the present Board of Trustees "Commissioners of Water Works" was appointed in 1896 with full power to commence the construction of a new plant for the city. The board consisted of the following members: Messrs. Aug. Herrmann, Maurice J. Freiberg, C. M. Holloway, Leopold Markbreit and Thos. W. Graydon. After the resignation of Mr. Thos. W. Graydon in 1897, Mr. Wm. B. Melish was appointed to fill the vacancy. The board appointed the late Mr. Gustave Bouscaren as its chief engineer, and Messrs. Chas. Hermany and Geo. H. Benzenberg as consulting engineers.

Several important modifications of the general arrangement of the new plant, as recommended by the preceding Engineer Commission, were made, and the preparation of detailed plans and specifications for the purpose of construction was commenced. It was decided to make an investigation of the best methods for purifying the Ohio River water, and with that end in view an experimental plant was established at Eden Park in 1899. Extended chemical and bacteriological studies were made of processes suitable for treating the river water. The results of this investigation were embodied in a report by Mr. Geo. W. Fuller, who conducted the work. In accordance with his recommendations the commission adopted the type of purification known as the rapid system of sand filtration, in which chemicals are used to assist the rapid filtration of the water through sand. Since the completion of the above-mentioned experimental work in 1899, further studies have been made, which have materially assisted in the development of those features of the filtration plant which seem to be best adapted to the existing local conditions.



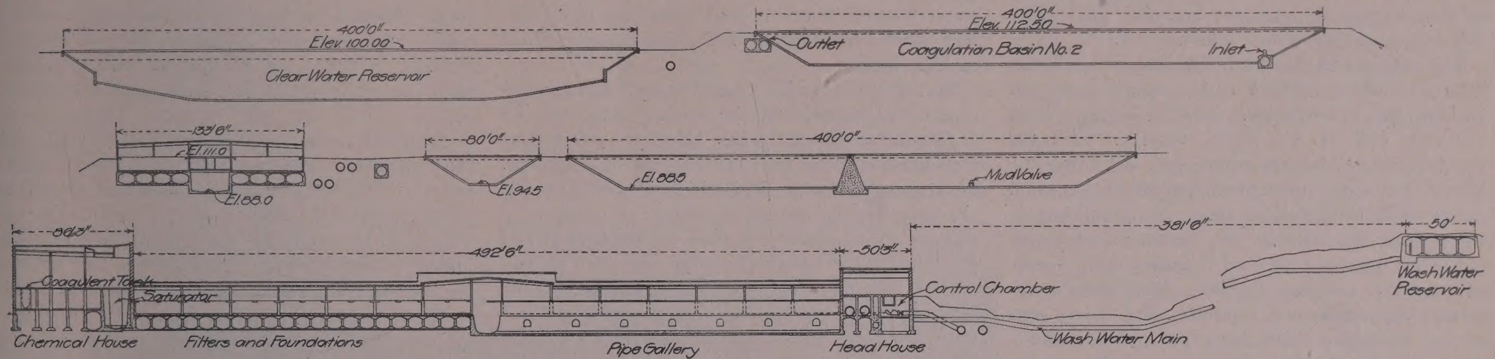
View toward Head-house from Chemical House.

The intake of the new water works is located about 6.5 miles upstream from the old intake and about 3,000 ft. above the point where the Little Miami River empties into the Ohio River. It consists of a pier, standing in the deep water of the river channel near the Kentucky shore, connected by a tunnel passing under the river bed to the uptake shaft in the pump pit of the pumping station, which is situated on the Ohio shore. At this station four pumps, each of 30 million gallons daily capacity, are installed to force the water through two cast-iron mains 60 in. in diameter to the settling reservoirs, which are located on the high ground about two-thirds of a mile from the river bank, and at an elevation of about 145 ft. above low water in the river.

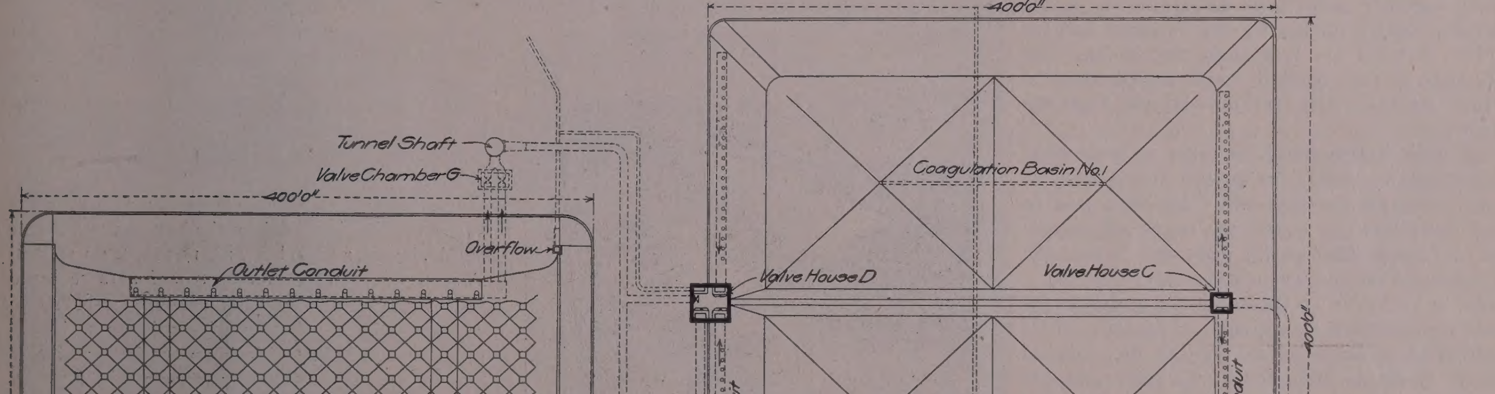
Settling Reservoirs.—The purification of the river water will begin in these settling reservoirs, where it is expected that 50 to 75 per cent of the sediment will settle out in the two or three days the water is permitted to remain in them. It is not expected that it will be necessary to apply chemicals to the water entering these reservoirs, reliance being placed upon the natural sedimentation of the clay particles to effect partial clarification. Exceptional conditions may arise, however, when partial coagulation of the sediment by chemicals may be desirable.

The reservoirs are situated in the valley of a branch of Lick Run, a small stream which empties into the Little Miami River. They occupy two ravines, the lower ends of which are closed by earthwork dams. In laying out these reservoirs the natural contour of the ground was followed as closely as practicable. Reservoir No. 1, the basin nearest the river, has a capacity of 158 million gallons, and Reservoir No. 2, which lies just east of the former and is separated from it by only a narrow strip of high ground, has a capacity of 187 million gallons. On the high ground dividing the two reservoirs are laid the two 60-inch cast-iron mains leading from the pumping station. At the ends of these pipes are located a number of valves, which permit the water to be diverted to either one of the two settling reservoirs as may be desired.

These reservoirs have a lining composed of concrete, asphalt and brick, similar to that used in the coagulation basins which are described in detail later. Around the rim of each reservoir is laid a high-pressure pipe line with hydrants at convenient intervals for the attachment of hose. When the reservoirs are being cleaned the deposited sediment may be readily flushed down the slopes of the basins by water taken from this pipe line. Openings into drains are placed at convenient intervals in the bottoms of the reservoirs and permit the mud to be flushed away through closed drains to a large open drain below the dams and emptying into Lick Run.



Cross-Sections through the Water Purification Works.



General Plan of the Works under Construction for Purifying the Cincinnati Water Supply.

Water will be drawn from these reservoirs through floating tubes 48 in. in diameter, which, by means of swinging elbows and floats, will draw the water continuously from a point about 2 ft. below the surface. Two of these tubes are provided for each reservoir. These reservoirs are to be operated on the fill and draw plan, one reservoir being filled while the other is being drawn off to the filter plant for subsequent treatment in the coagulation basins.

From the settling reservoirs the water will pass through the floating tubes described above to pipes 60 in. in diameter, which are laid in 16-ft. circular tunnels under the dams. These effluent pipes enter valve shafts on the outside of the dams, one shaft being placed opposite each reservoir. The effluent pipes in each shaft rise vertically and then turning at right angles pass through the side of the shaft and connect outside the latter with two 60-in. cast-iron pipes laid along the embankment. The latter pipe lines are cross-connected so that water may be passed through either or both of them as may be desired. Through these 60-in. pipes the settled water will be conveyed to the headhouse of the filter plant. The settling reservoirs can be by-passed and the water taken directly into the headhouse of the filter plant from the pumping station. At low stages of the river when the water is quite clear this method may be employed.

Filter Plant and Coagulation Basins.—The site of the filter plant and coagulation basins is a little to the northwest of the settling reservoirs and on the opposite side of the New Richmond pike. It occupies an area of approximately thirty acres. The filter plant includes three coagulation basins, twenty-eight filters, with headhouse and chemical house; a clear-water reservoir, and the piping connecting various parts of the plant. The coagulation basins occupy the southeasterly portion of the site, nearest the settling reservoirs; the clear-water reservoir the northeasterly portion, nearest the city, and the filters and their appurtenant buildings an intermediate position to the west. A railroad siding enters the grounds on the north and will be extended into the chemical house.

The coagulation basins are formed partly in excavation, and partly in embankment. Basins Nos. 1 and 2 are separated by a concrete dividing wall, extending across the middle of a basin 400 ft. square at the top of the slope. The area of Basin No. 3 at the top is 400x80 ft. The clear-water reservoir is formed principally in excavation, and is 400 ft. square at the top. The capacities of these basins are as follows: Basins Nos. 1 and 2, about 10 million gallons each; Basin No. 3, about 2 million gallons; and the clear-water reservoir about 19 million gallons.

The entire area of the filters and the galleries between them is covered with a house about 500 ft. long and 137 ft. wide. The headhouse at the southern end of the filters, together with the chemical house at the northern end, form with the filter house a continuous building 629 ft. long and of the width mentioned above. In addition to offices and laboratories, the headhouse contains means for metering and for reducing the pressure of the water entering the filter plant, and for applying sulphate of iron thereto. The lower part of the headhouse contains a pump room and a pump well for the wash water pumps. The chemical house will be used for the storage of chemicals, and their preparation for application to the water. Boilers for heating the buildings and for other purposes are located in this house. The location of the chemical house was determined from the ready accessibility of its site from the railroad.

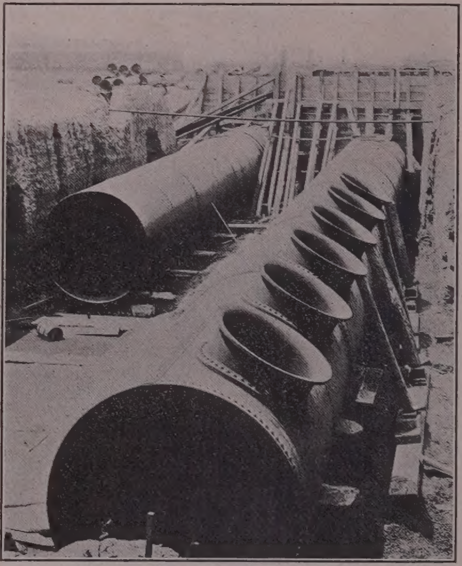
Method of Operation.—In order to understand better the reason for the general arrangement of this plant and for some of its details, it may be well to follow the course the water will pursue in its passage through the plant and to note the treatment it receives at various points. The chemicals to be used in coagulating and purifying the water are sulphate of iron and caustic lime. These are to be prepared as solutions in the chemical house at the northern end of the plant, and will be conveyed to the southern end of the plant and applied to the water before it passes to the coagulation basins.

The raw or settled water will pass to the headhouse through six 36-in. cast-iron pipes, branching from the 60-in. mains from the reservoirs. These six pipes terminate in six concrete chambers in the foundations of the headhouse, each chamber being about 20x6 ft. and 14 ft. deep. At the end of each pipe and within the corresponding chamber are a 36-in. electrically-operated valve and two 28-in. pressure-controlling valves, actuated by adjustable floats moving in perforated concrete stilling boxes. By means of these controllers the pressure of the water will be reduced from that due to the level of the settling reservoirs to that of the coagulation basins, a maximum difference of about 35 ft. Each controller chamber can be closed by means of stop planks and drained so as to make the valves accessible.

Passing from these chambers, the water will enter two channels in the headhouse, each about 3 ft. wide and 12 ft. deep. Each of these channels contains a grid of pipes for the discharge into the water of the sulphate of iron solution coming from the chemical house. Each grid consists of two 2-in. vertical cast-iron screw-jointed pipes, extending down through the whole depth of the channel and perforated with ¼-in. holes. The water will next enter two 60-in. cast-iron pipe lines at the beginning of each of which, and still located within the headhouse, is a 60-in. Venturi meter. These meters will indicate and record the rate at which water is passing through the plant, and aid in determining the rate at which coagulant is to be applied, as well as show the total quantity of water treated.

Leaving the headhouse, the water will pass to valve chamber B, at the southwest corner of coagulation basin No. 3. Here the water will receive its charge of caustic lime in the form of lime water, which will enter the bottom of the chamber through a 24-in. cast-iron pipe from the chemical house. Chamber B is divided by a cross wall and is furnished with sluice gates, so that the water may be passed in any of the following three ways: from the headhouse to basin No. 3; from the headhouse to basins Nos. 1 and 2, or from basin No. 3 to chamber E, at the outer end of basin No. 3. Flow in the two directions last mentioned can occur at the same time. The water passing to basins Nos. 1 and 2 may be further controlled at chamber C so as to enter either or both basins.

In the three basins coagulation and sedimentation will occur, and the settled water will be drawn off continuously just below the surface by conduits laid along the northern side of the basins. On the outlet side of the basins, chambers D and E are arranged to control the flow of water in a manner corresponding to that in chambers C and B. Thus these basins are so arranged as to permit of varying periods of sedimentation. They may be operated singly or in combination. When the plant is operating at the rate of 112 million gallons daily, theoretical periods of coagulation and sedimentation of 0.4 hr., 2.1 hr., 2.6 hr., 4.3 hr. and 4.7 hr., respectively, may be obtained by the proper manipulation of valves in the several valve chambers. The settled water drawn from these basins will pass directly to the filters in the filter house. Before passing to the filters provision is made, however, for a secondary treatment with chemicals by means of a grid in valve chamber E similar to those in the headhouse. If necessary the water after such treatment may receive a further short period of subsidence (0.4 hr.) in the small coagulation basin No. 3, being passed through this basin in a direction opposite to the ordinary flow.


Pipes at South End, Basin 3.

The piping forming the various inlets, outlets and connections is 84 in. in diameter; and except for the inlets of basins Nos. 1 and 2, which are of concrete, is of steel ½ in. thick. The steel pipe is enclosed in a concrete lining, partly as a protection against rust, and partly to add to the security of the embankments in which the piping is laid against washing away in case of accident to or leakage from the steel pipe.

All inlet and outlet pipes are provided, along their full length, with cast-iron nozzles opening into the basins. The outlet pipes of all basins and the inlet pipes of basin No. 3, which may at times serve as an outlet, have the openings of the nozzles at a depth of 4.0 ft. below the high-water level. The inlet conduits of basins Nos. 1 and 2 have the openings of the nozzles at a depth of 16 ft. below high water and about 6 ft. above the bottom of the basins.

The sludge deposited in the basins will be removed periodically through cast-iron pipe drains laid underneath the bottom. There are two drainage outlets for each basin, each outlet being controlled by a plug valve operated from the top of the embankment by hydraulic power. After the water has been drained through these valves from the basin which it is proposed to clean, the sludge will be flushed out by means of hose streams through the same openings. Hose couplings attached to a pipe carrying water under 100 lb. pressure are located at intervals around the tops of the slopes, so that the maximum distance to any point of the basin does not exceed 225 ft.

An overflow is provided from all three basins through a 30-in. cast-iron pipe leading from chamber D. The sluice valves in chambers D and E, which control the outlets of the basins, are not placed at the ends of the outlet pipes, but are placed in walls within the chamber and beyond the ends of the pipes. The tops of these walls are at El. 110, as is also the top of the wall surrounding the upper end of the overflow pipe; so that when the water in the basins exceeds this elevation it will pass off through the overflow, whether the sluice gates are shut or not.

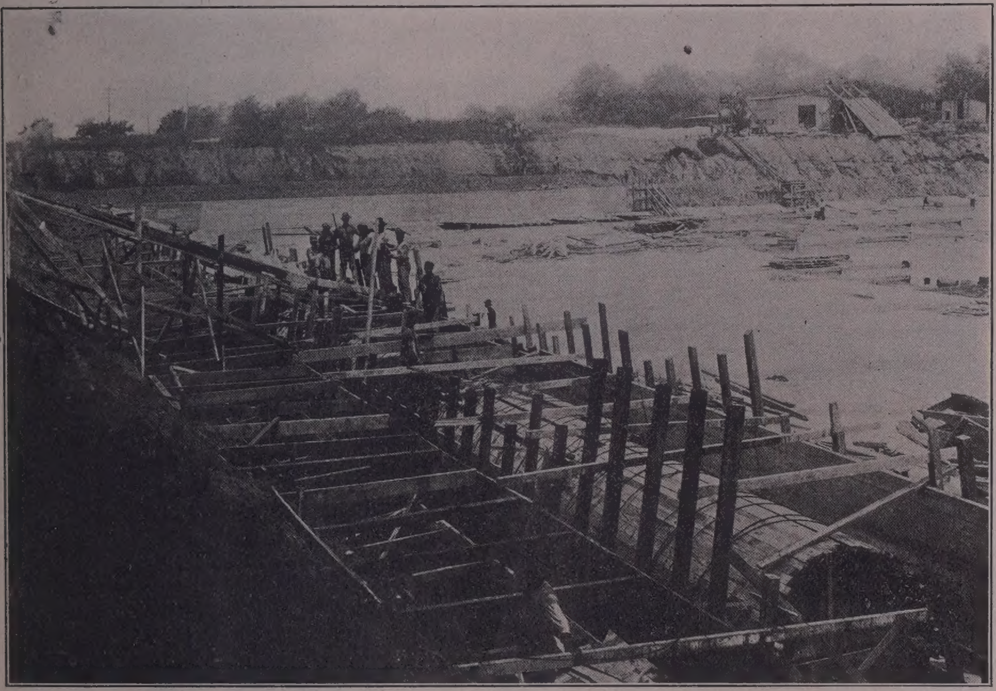
Details of Construction.—The coagulation basins are amply protected against leakage. The excavation for them is largely in sandy material, and is carried below the finished surface of the lining a distance varying from about 4 ft. deep in the bottom to about 2 ft. deep at the top of the slopes. A covering of the most water-tight material available, a sandy clay from a borrow pit in the vicinity, is placed on the bottoms and slopes in 6-in. layers, and rolled with 17-ton steam rollers. Parts of the slopes too narrow for these large rollers are rolled with an asphalt street roller weighing about 3½ tons. This latter roller is, however, too light to break up the lumps of clay thoroughly. Upon this clay cover a 6-in. layer of concrete is placed, except that on the upper portion of the slopes, a 12-in. layer of broken stone is first laid on the clay and then covered with the concrete. The concrete is placed in alternate strips, 10 ft. wide. Parting joints ⅜ in. wide and 3 in. deep are afterward cut by driving tee-irons along the edges of the strips and across these strips at intervals of 10 ft., dividing the surface into 10-ft. squares. These joints, after the concrete is set, are cleaned and dried and filled with asphalt.

The entire surface of the concrete is then covered with a priming coat of asphalt dissolved in benzine, spread very thin with a brush. Upon this is poured and spread a layer of hot asphalt, about ¼ in. thick. Upon the slopes the ¼-in. layer is poured in two portions, between which is stretched a layer of coarse burlap to prevent the asphalt from moving down the slope. The asphalt used is Bermudez, with a small amount of liquid California maltha, generally about 20 per cent., mixed with it, sufficient to make a material which will not easily run when warm nor be too brittle when cold. The mixture is heated in a kettle for about half a day before being applied, so that all moisture is driven off.

Brick are laid flat, herring-bone fashion, upon the asphalt. After being laid they soon embed themselves in the asphalt, so that it is difficult to remove them. The brick are vitrified shale brick, so hard as to absorb not more than 2 per cent. of water when immersed for 48 hours. They are provided with lugs projecting from their sides and ends, so that when laid a fairly uniform joint about ⅛ in. wide is kept without especial care in placing them. These lugs are quite necessary on the slopes, where the bricks would soon slide into contact with each other, no matter how carefully placed.

After the brick layer has become well bedded in the asphalt, the joints are filled with grout consisting of one part of Portland cement and two parts of sand. A very thin grout is first applied and flushed into all the joints. Afterward a second application is made, of much dryer grout, brushed over the surface and filling all voids remaining from the first application. Around the tops of all three basins there is a curb of concrete blocks built in place, in alternate 8-ft. lengths. This curb is three and one-half feet deep and one foot thick.

The coagulated water leaves chamber E in two 60-in. cast-iron pipes, which enter the filter house at the middle of its length. Turning, one northward and one southward, they pass longitudinally through the pipe gallery, which extends the full length of the house between the rows of filters. The two 60-in. effluent pipes from the filters are similarly located at a lower elevation, and take the water out in the reverse direction to that in which it enters. The wash water main is located between the influent and effluent pipes, and is a single 36-in. cast-iron pipe extending the full length of the house in a straight line. The main drain is also a single 36-in. cast-iron pipe and is below the effluent pipe.



Forms for 7-Foot Inlet Conduit and Clear Water Basin.

Filtration and Method of Washing Filters.—The method of handling the water in the filters will not differ materially from that followed in most plants of this type. The various devices for quickly and easily operating the filters will be more fully described further on. The manner of washing the sand bed of the filters, however, may be noted here, as it will be a rather marked departure from the present established methods. No compressed air will be used, nor any mechanical device employed to produce agitation of the sand prior to or during the introduction of the wash water. The latter will be forced into the filters through the strainer system at a rate of 2.0 to 2.5 cu. ft. per minute per square foot of filtering area, and under a head of about 40 ft. The velocity of the rising water is alone depended upon to float and agitate the sand bed and to wash off the mud at the top. This method was carefully studied experimentally for some time and the results thus obtained were sufficiently convincing to warrant its adoption.

In order to make this method of washing possible in a filter bed in which a coarse sand or a graded layer of gravel is used as a base for the filter sand proper, it is necessary to hold the foundation layer in place in some manner to prevent its displacement by the velocity of the rising wash water. This is effected in this plant by a brass wire screen laid directly above the gravel layer and below the filter sand. The meshes of the wire cloth are of such size as to prevent the passage of the gravel through them, but permit the passage of the grains of filter sand. With such a screen the velocity of the rising wash water has no effect on the gravel and the latter is thereby enabled to remain in position and fully protects the strainer system against the passage of filter sand into it.

The time occupied by the operation of washing will probably be from fifteen to twenty minutes. The actual period of applying wash water will be not over four minutes. The time required to open and close the large valves of a filter will form the greater part of the time the filter will be out of service. The metering of the wash water applied, as well as the total inflow to the plant will permit an accurate record of the percentage of wash water chargeable to the operation of the plant to be kept.

The filters consist of 28 independent rectangular boxes of reinforced concrete 32x50x10 ft. deep inside. Each filter is divided into two parts by a central gutter 3 ft. wide inside and having the full depth of the tank. This gutter will remove the dirty wash water emptied into it by twelve lateral gutters. The lateral gutters are rectangular in shape with a V-shaped bottom. They are 14 in. wide and are of reinforced concrete 2 in. in thickness. The tops of their sides form weirs for the removal of the wash water 30 in. above the sand level. The filters are similar to those at some other plants, except that, as they are covered entirely by the roof of the building above, they are left open at the top, and are merely crossed at intervals by concrete walks, which are necessary to tie the tops of the walls together.

The filters are separated by galleries running longitudinally and transversely into four groups of seven filters each. They are supported upon a concrete foundation consisting of a groined arch roof resting upon piers carried by groined arch footings. This foundation serves as a chamber providing accessibility to the effluent piping beneath the filters; and also extends the masonry down to earth more suitable as a foundation than that found at the level of the bottom of the filters themselves. The chambers of the foundations are not, as in other plants, utilized as a clear water reservoir.

The longitudinal or pipe gallery and the transverse gallery extend 4 ft. lower than the filter foundation. The 36-in. main drain is laid below the bottom of these galleries, so as to drain them, and is surrounded with concrete. The effluent, wash water and influent mains, located in this order above the main drain, are supported by concrete piers, about 1 ft. thick and 7 ft. wide, entirely surrounding the effluent and wash water pipes, and extending up under the influent pipes. The piers also form a partial support for the floors, of which there are two; one a little higher than the top of the filter foundation, and one at the top of the filters. The former is called the motor gallery floor and the latter the filter gallery floor.

Each filter is governed by means of rising stem gate valves, operated by electric motor stands located upon the motor gallery floor. The motors are controlled from switchboards located upon the filter gallery floor. The filter gallery floor consists merely of a central walk extending along the center between the filters, and branch walks leading to the switchboard, so that the greater part of the floor is open and the operator at the swichboard can plainly see the motors and the rising stems of the valves. The position of the valves, whether open or closed, is also indicated by lights upon the boards.

Each switchboard consists of ten controller panels, operating the ten valves of two filters. These panels are placed in two sets of five each, back to back and 4 ft. apart. Closing the space at one end of the switchboard is a marble sink with a high back. The sample pumps from the effluents of the two filters will discharge into this sink. The sink is wide enough so that its top forms a table upon which rest the two loss-of-head gauges for the filters.

The effluent rate controllers are of the enclosed type and are located at the bottom of the gallery. They consist of double-disc balanced valves moved by hydraulic power from an outside source. The application of the hydraulic power is controlled by an auxiliary valve containing a diaphragm, which is moved by the change in difference in pressure of the water on the two sides of a fixed orifice in the effluent pipe.

The strainer system of the filters consists of perforated brass plates covering channels in the concrete, with the addition of a wire screen above for holding down the gravel while the filter is being washed, as before described. Built into the bottom of each filter there are 112 3½-in. cast-iron risers from the effluent piping beneath. These are in four rows across the filter, the rows being 12½ ft. and the individual pipes 12 in. center to center.

The bottom of the filter tank is at first built level and smooth. Then, extending 50 ft., the full length of the filter, ridges of concrete 11 in. high, 9½ in. wide at the bottom and 2¼ in. wide at the top are built 12 in. center to center, and between the riser pipes. At 3 in. above the bottom a shoulder is made on each side of each ridge. Rows of curved brass plates 1/12 in. thick, perforated with 64 3/32-in. holes per linear foot, span the spaces from shoulder to shoulder, and thus form 28 longitudinal channels in the filter, each tributary to four riser pipes. The strainer plates are each about 3 ft. long, and are laid in mortar and red lead and anchored every 12 in. In the wedge-shaped spaces above the plates gravel is placed in four layers graded in size from 1 in. to 1/12 in. Over the top of this gravel and the tops of the ridges a No. 20 brass wire screen having 10 meshes per inch is stretched and bolted to the concrete. Above the screen is placed sand to a depth of 30 in., having an effective size of about 0.35 mm. and a uniformity coefficient of 1.60.

The wash water for the filters will be provided by two centrifugal pumps, electrically operated, of a capacity of 2,500 gal. per minute each. These pumps are located in the basement of the headhouse, and will be supplied with water from a pump well beneath, into which water from the filter effluent mains will flow directly. The wash water is to be stored in a covered concrete reservoir on a hill about 400 ft. from the headhouse. Float switches at this reservoir will automatically start and stop the pumps. The discharge from the pumps leads into a 36-in. main which connects the reservoir with the wash water main in the filter house.

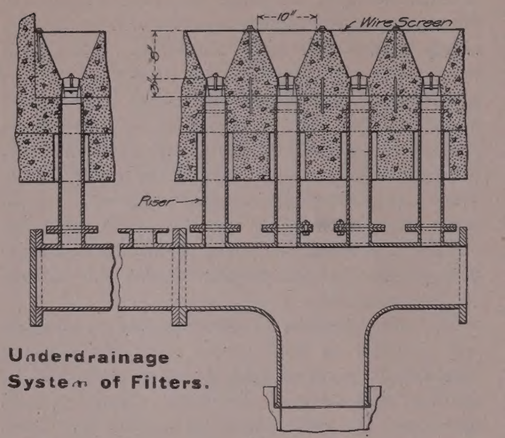
Clear-Water Reservoir.—The filtered water will pass from the filters to valve chamber F, where valves are provided to admit the water to the clear-water reservoir, or to turn it to a by-pass running around the side of the reservoir. The inlet to the reservoir consists of an 84-in. reinforced concrete conduit, extending the full length of the west side of the reservoir, and having pipe castings set at intervals in the top. These castings are about 7 ft. below high water, but they can be extended upward, if desired, to provide means for aeration of the water. The outlet conduit is of the same size and material, and is built below the bottom along the opposite side of the reservoir, and has openings in its top for its whole length. From this conduit the water will pass through pipes to a tunnel about 4⅘ miles long, which will convey it to the main distributing pumping station in the city, situated on Eastern Ave. at Torrence Road.

The construction of the lining of the clear-water reservoir is similar to that of the coagulation basins, except that provision is made for a possible future covering with concrete arches. For this reason groined arch pier bases are formed upon the flat part of the bottom, and the bottoms of three of the slopes are cut away by retaining walls, which may serve as the outer walls of the covered reservoir.

Preparation of Iron and Lime Solutions.—The large volumes of solutions necessary for treating the water will be prepared in the chemical house at the northern end of the filter house. The volume of lime water needed under maximum conditions would amount to about 5 per cent. of the total flow through the whole plant. The iron solution can, of course, be made more concentrated and its volume will be much smaller. No pumping of solutions will be necessary as they flow by gravity to the points where they are applied to the water. Variations in the volumes of the solutions being applied are not, as a rule, contemplated, reliance being placed upon a change in the concentration of the solutions to effect the application of different amounts of the lime and iron which may be required. However, ample provision has been made for varying the volumes of the solutions if desired.

The iron solution will be prepared in a series of five reinforced concrete tanks. Each tank is cylindrical inside, 5 ft. in diameter and about 12 ft. deep below the water line. A 12-in. cast-iron pipe, open top and bottom, is placed within this cylinder, and contains, near its top, a small propeller pump actuated by an electric motor upon the floor above. This pump will draw the solution up through the pipe to the top of the tank, whence it will pass downward again between the pipe and tank. A complete circulation of all the liquid will be effected about once in two minutes. The sulphate of iron will be applied within the 12-in. pipe just below the propeller. It is expected that a rapid solution of the solid sulphate of iron will be brought about in this apparatus.

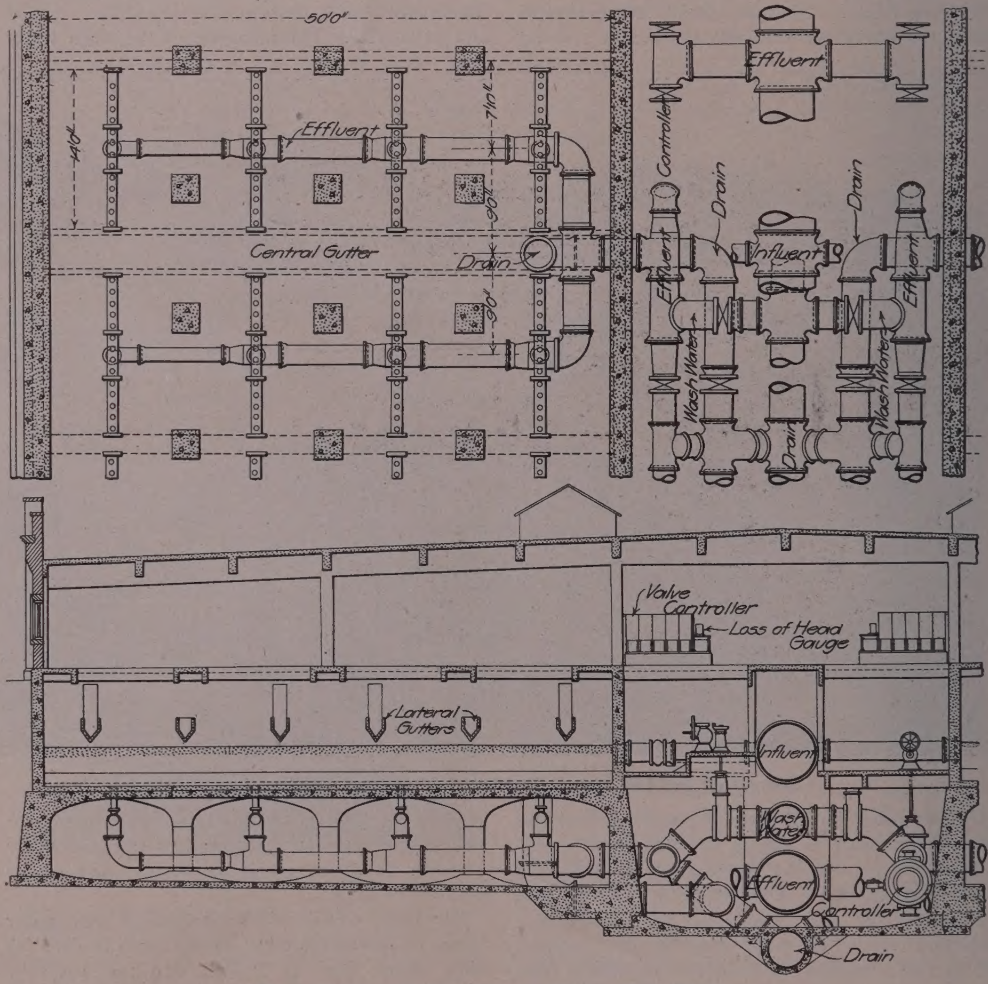
From three of these tanks the iron solution will flow by gravity through duplicate 3-in. cast-iron pipe lines to the point of application to the raw water in the channels of the headhouse. The other two tanks are for the purpose of preparation of a solution of coagulant, with which to make a secondary application in chamber E. This secondary application will be necessary only in case of emergency, such as when the water has been settled too long and needs additional coagulation before it can be properly filtered, or when the water has not been sufficiently coagulated and is about to enter the filters in a too turbid condition.



Underdrainage System of Filters.

Caustic lime will be converted into lime water by first slaking the solid lime in slaking tanks, of which there are six. Three of these tanks are intended for use at one time and three are held in reserve for cleaning. Water at a temperature of about 120° Fahr. will be used for slaking. The solid lime will be dumped into the tanks and its slaking promoted by stirring with mechanical rakes. The milk of lime thus formed will flow into lime water saturators in which the suspended lime will be eventually converted into lime water.

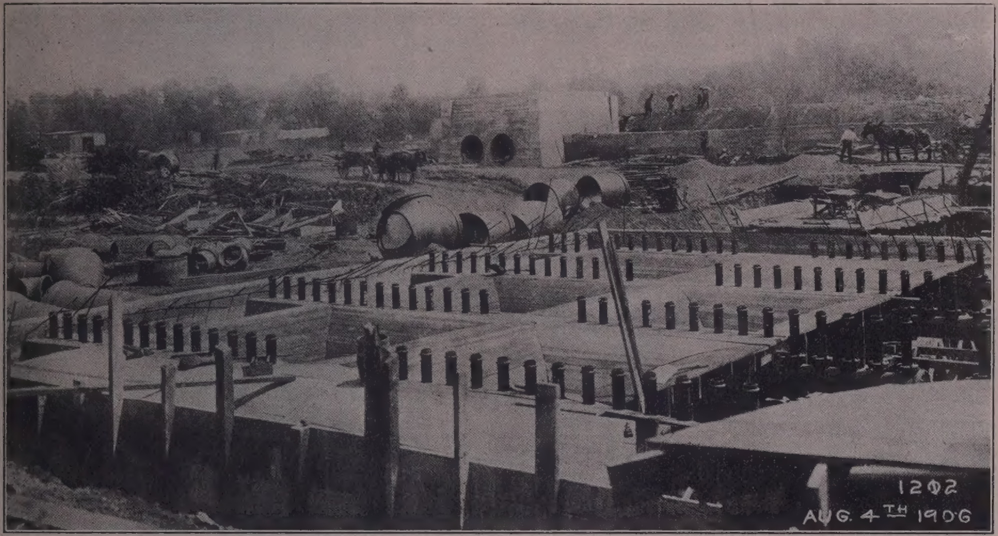
The slaking tanks are of steel, 6 ft. 4 in. in diameter and about 3 ft. deep. They rest partially upon the saturators below and are partly suspended from the second floor of the chemical house. The liquid will stand in them about 2 ft. deep and the milk of lime will be drawn from them at a point about 9 in. below the surface. The solid lime will be applied through an opening in the floor above each slaker, provided with a grating to keep out large lumps. Over the opening is a box or hood of sheet iron, within which the lime will be applied, provided with a vent pipe extending through the roof of the house. When the door of the hood is opened for the purpose of applying lime, an exhaust fan will automatically be started, which will create a draft through the hood and prevent steam and lime from entering the room. The water for slaking will be heated in six Tobey water heaters. The nominal daily capacity of each slaking tank is sufficient for the conversion of 8 tons of lime into a 10 per cent. milk of lime daily. The accumulation of waste material in the tank will be disposed of by flushing it out with a hose stream through a drain in the bottom of the tank.



Part Plan and Section of Filter Bed Piping.

The saturators are four octagonal tanks of reinforced concrete 19½ ft. across at the top and about 23 ft. deep below the water line. They are built octagonal so as to have a more compact arrangement than if circular, and so as to avoid the dead corners and necessarily heavy sides due to a square shape. The walls are 9 in. thick at the top and 2½ ft. thick at the bottom. The bottoms slope sharply to the drain valve at the center. The outlet for the lime water is over a weir into an overflow channel formed in concrete around the sides of the saturator near the top.

Settled water will be used for making the lime water on account of the large volume of water required. Its rate of flow to the saturators will be governed by automatic controller valves of the type used in the filters. The water will enter the saturators through the same pipe which will carry the milk of lime, and the two liquids thus mixed will pass to the bottom of the saturator through a flaring tube. The water with its dissolving lime will slowly rise upward through the tank after passing out of the flaring inlet tube, and by the time it reaches the overflow the lime will all have gone into solution. Mechanically-operated stirrers at the bottom of the saturator are provided to bring about an intimate mixture of the milk of lime and the added water, and thereby produce a rapid solution of the lime particles in suspension. A period of 35 minutes will be available for saturation while the solution is passing through the tank. Removal of deposited sludge in the saturators will be effected by periodically raising a plug in the bottom of the tank, which if lifted quickly, will produce a sudden outflow of water, carrying with it the accumulated sludge. One saturator is to be held in reserve for repairs and cleaning. The method of varying the amount of lime it is desired to add to the water is the same as that to be used with the iron solution. The weight of lime dumped into the slaking tanks will be varied, thereby changing the concentration of the solution. A 24-in. cast-iron pipe is provided to convey the lime solution by gravity from the chemical house to valve chamber B, where it will enter the raw water.



Forms for Top of Filter Foundation and Effluent Piping.

The sulphate of iron and caustic lime will be received in 100-lb. bags and unloaded from cars standing on a track running through the center of the chemical house. Unloading platforms on both sides of the track, together with sack elevators on either side, will make the handling of chemicals easy and rapid. Storage is provided on both floors of the chemical house, and about one month's supply of chemicals, under maximum conditions of consumption, can be stored.

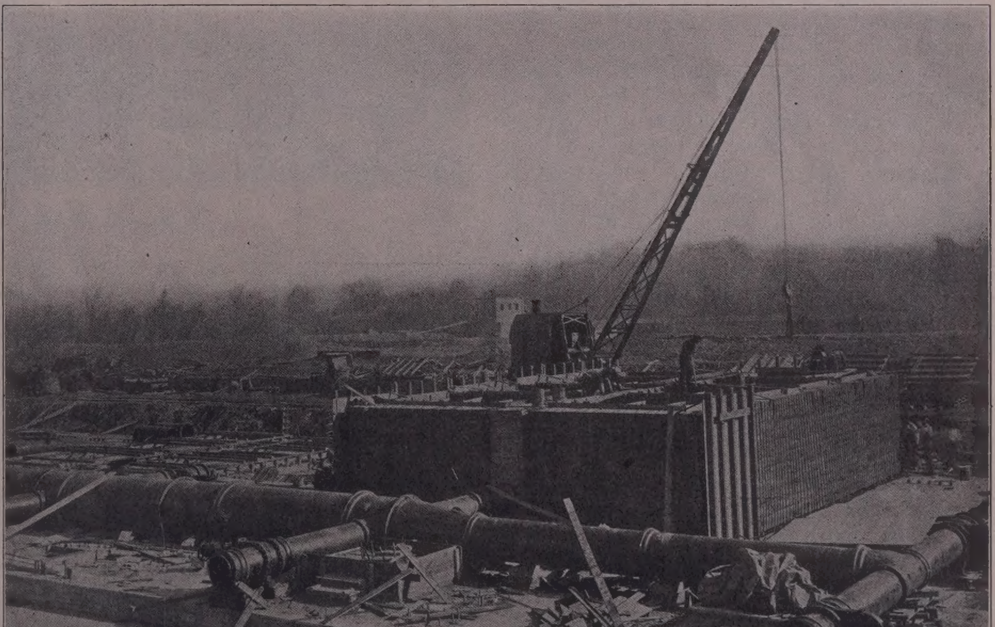
Laboratories and Offices.—The laboratories are located on the west side of the headhouse and are commodious and well equipped. They consist of two chemical laboratories, one for general chemical work and one for the analysis of water, and a bacteriological laboratory and preparation room. A chemical storeroom is also provided for apparatus and supplies. A two-ton ammonia compression refrigerating machine, installed in the basement of the headhouse will cool the large refrigerator in the laboratories and furnish ice for cooling drinking water.

It is expected that the data obtained in the laboratories will be constantly studied for the purpose of properly controlling the operation of the plant. The chemical solutions used will be continuously tested to ascertain their strength and to control their preparation. The water both before and after treatment will be subject to chemical and bacteriological examination. It is believed that a careful study of the information so obtained will not only enable a better quality of water to be produced, but will make possible the operation of the plant at the lowest possible cost.

In the headhouse are also located the general office for clerical work, and the superintendent's office. Lavatories and a locker room are also placed in the headhouse for the convenience of the force employed at the plant.

Cost of the Plant.—The total cost of the filtration plant (not including the settling reservoirs), will be about $1,285,000. This cost may be divided into the following parts:

Filters, with foundations, superstructure and piping complete	$487,500
Coagulation basins, with inlet and outlet conduits and drains	206,300
Clear water reservoir, with inlet and outlet conduits and drains	136,500
General piping, connecting settling reservoirs, coagulation basins, filters and clear water reservoir, and drain piping for grounds, including valves, valve houses, meters, etc.	215,400
Buildings for laboratories, offices, wash water pump room, and for preparation, storage and application of lime and iron	134,800
Wash water pumps, piping and reservoir	23,600
Apparatus for preparation and application of lime and iron	46,100
Grading grounds, lighting grounds, etc	35,000
Total	$1,285,000



Filter Forms and Influent Filter Piping.

The costs of some of the above parts of the filtration plant may be still further divided, as follows:

Filters.—(Net area, 39,200 sq. ft. Nominal capacity, 112 million gallons daily.)	
Earthwork	$6,000
Filter foundations and pipe gallery	55,000
Filter tanks (including central and lateral gutters)	47,300
Filter piping and valves (including controllers)	205,000
Operating switchboards and indicating and sampling apparatus	24,600
Strainer system (brass plates, wire screen and concrete channels)	47,900
Sand (3,650 cu. yd.) cost estimated	20,000
Gravel (670 cu. yd.) cost estimated	3,300
Main wiring for light and power	8,000
Superstructure over filters (area 65,000 sq. ft.), including heating and lighting	70,200
Total	$487,300
Coagulation Basins.—(Combined area, 192,000 sq. ft.; combined capacity about 22,000,000 gal.)	
Earthwork	$57,000
Concrete, asphalt and brick lining	65,700
Concrete dividing wall betwen Basins 1 and 2	38,500
Piping (steel, cast-iron and concrete)	45,100
Total	$206,300
Clear-Water Reservoir.—(Area, 160,000 sq. ft.; capacity about 19,000,000 gal.)	
Earthwork	$52,900
Concrete, asphalt and brick lining	68,900
Piping (steel, cast-iron and concrete)	14,700
Total	$136,500
Wash-Water Apparatus.	
Wash-water pumps and wiring (2 pumps with capacity of 2,500 gal. per minute each)	$7,800
Wash-water reservoir (capacity 190,000 gal.)	7,200
Cast-iron pipe, valves and Venturi meter	8,600
Total	$23,600
Apparatus for Preparation and Application of Lime and Iron.—(Nominal capacity, a rate of application of 24 tons of lime and 32 tons of iron per day.)	
Concrete and steel tanks for saturators, slakers and coagulant tanks	$14,500
Cast-iron and brass piping to and from tanks, valves, rate-controllers, meters, etc	20,200
Stirring machinery, lime hoods, water heaters, etc., including electric wiring	11,400
Total	$46,100

The preliminary studies and investigations in connection with the purification plant were carried on under the direction of the late Mr. Gustave Bouscaren, chief engineer for the Commissioners. He also designed and commenced the construction of the settling reservoirs and the coagulation basins. Since his death the design and construction of the filtration plant and the completion of the unfinished work on other portions of the plant have been conducted under the direction of Mr. George H. Benzenberg, acting chief engineer, Mr. Chas. Hermany continuing as consulting engineer. Mr. Geo. W. Fuller acted as consulting engineer in the design of the filtration plant. Mr. Clifford N. Miller is assistant engineer in charge of the office, and Mr. Wm. C. Jewett is the resident engineer in charge of the construction of the settling reservoirs. Mr. G. W. Drach, architect, prepared the plans for the buildings of the filter plant and for their systems of heating and lighting. Mr. E. G. Manahan is assistant engineer in charge of the design and construction of the filtration plant, and Mr. J. W. Ellms chemist in charge of lab oratory, has conducted investigations relating to some of the chemical engineering and hydraulic problems involved in the design of the filters.

The contractors for the completion of the settling reservoirs are Keeling & Ridge, of Cincinnati and Pittsburg, and the Kirchner Construction Co., of Cincinnati. The principal contracts on the filtration plant are held by the Kirchner Construction Co. and the Eid Concrete Steel Co., of Cincinnati, for the construction of the filters, basins, buildings and piping; the United State Cast Iron Pipe & Foundry Co., for furnishing cast iron pipe and all special castings; the Fairbanks Co., of New York, and the Coffin Valve Co., of Boston, for valves; the Norwood Engineering Co., of Florence, Mass., for the operating machinery, and the Greer Filter Co., of Philadelphia, and the Michigan Wire Cloth Co., of Detroit, for the strainer system of the filters.

The Water Supply System of Brockton, Mass.

The works with which Brockton, Mass., is securing a supply of water from Silver Lake, 11½ miles from the city, include a pumping station at the lake; 225 ft. of 30-in. intake pipe, extending from a screen-well on the shore into the lake; about 61,000 ft. of 24-in. force main, leading from the pumping station to the city; and a riveted steel standpipe, 35 ft. high and 75 ft. in diameter. These works and the conditions which made their construction necessary, were described by Mr. Charles R. Felton, city engineer of Brockton, in a paper read before the New England Water Works Association, from which, through the courtesy of Mr. Felton, these notes have been taken; the paper in full will be found in the "Journal" of the Association.

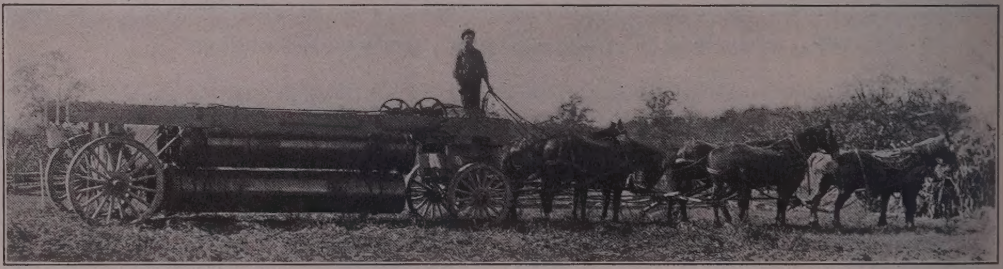
Brockton is a city of about 50,000 inhabitants, and prior to 1903 took its water from an artificial reservoir situated in the town of Avon, and having an area of about 90 acres and a watershed of 3¼ square miles. The water from this reservoir, while very highly colored, was not unhealthful, and its poor quality was not the primary cause for seeking a new supply. The lowering of the reservoir to a depth of about 7 ft. below the rollway during the year 1899 led to the serious consideration of a new water supply, which had already received attention from Mr. F. Herbert Snow, formerly city engineer, and Mr. Horace Kingman, superintendent of water works. As the estimated supply procurable from the Avon reservoir in a dry year is only 1,500,000 gal. per day, and the present average use of water in Brockton is nearly 2,000,000 gal. per day, it is evident that the consideration of a further supply was taken up none too soon.

Mr. Felton, having been asked to submit a statement of all possible sources of supply to some expert, selected Mr. Desmond Fitzgerald, who, after examining a number of projects, reported in favor of Silver Lake. The selection of this source, on account of its limited watershed, was, to a certain extent dependent upon the amount of water deemed necessary for a future supply. According to a table prepared by Mr. Felton, the population of Brockton, in 1892, was 29,643, and the daily consumption of water per capita was 25 gal. At this time the city had 43.74 miles of water mains. In 1905 the population was 47,792, the daily consumption of water per capita was 35.6 gal., and the mileage of mains had become 97.366. Throughout the intervening period the yearly increase in both population and water consumption per individual was very steady and seemed to warrant the assumption that not before 1930 will the daily water consumption per capita reach 45 gal., which was the amount provided for in designing the new system.

Silver Lake has, at high water level, an area of 644 acres and a storage capacity of 5,371,000,000 gal. It has a maximum depth of 72 ft. and its elevation is 50 ft. above the city base. Its total watershed, including the water surface, is 4.4 square miles. The total population on the watershed in 1897 was 50, or 18 to the square mile. On account of the great storage capacity of Silver Lake, Mr. Felton points out, the date when a further supply of water will be required is not the date when the consumption equals the amount of water which the watershed would supply continuously. Under the estimated probable conditions of increase the Silver Lake supply can be drawn on for 18 years without ever drawing the water down to a point where it would not rise within 2 ft. of high water every year.

The plant at the pumping station consists of two 264-h.-p. horizontal water-tube boilers supplied by the Aultman-Taylor Co., and a 6,000,000-gal. vertical, triple expansion, crank and flywheel pumping engine furnished by the Barr Pump Co. The independent boiler feed pump, electric lighting set, air compressor for cleaning boiler tubes, the machine tools, and a Green economizer cleaner are all run by a small water motor discharging back to the lake. A brick chimney 100 ft. high with an inside diameter of 4 ft. at the top serves the boilers.

About 50 ft. from the pumping station in the shore of the lake, is a screen well 12 ft. in diameter, from which a 30-in. intake pipe extends 225 ft. into the lake. The screen well is provided with a double set of ¼-in. screens which slide in grooves. This well was very difficult to construct, owing to the fact that the material excavated was a fine quicksand which boiled up nearly as fast as it could be removed and settled the ground for a radius of 50 ft. in some directions. The work necessitated driving tongued and grooved sheeting 12 ft. below the bottom of the well. Owing to the difficulty experienced with the pump well, no attempt was made to pump out the sheeting in the lake, but the material was excavated with a small orange-peel bucket and a stiff-leg derrick. The last section of the pipe, 150 ft. long, was made tight with wooden heads in each end and was floated out to place and sunk by admitting water into it through rubber tubes. It was necessary to excavate and make one connection where the two sections joined. The end of the pipe rests on a concrete block about 3 ft. above the lake bottom.



A Special Pipe Truck Used at Brockton.

The great length of the force main made a difference in cost of about $100,000 between the various trade sizes of iron pipe which might have been used; that is, 20-in., 24-in., or 30-in. pipes. A 24-in. pipe was finally selected and fulfilled the conditions nearly enough to make it unnecessary to attempt a special size between the usual trade sizes. In the street the top of the pipe was generally placed about 4 ft. below the surface, while in private land, its depth was about 3½ ft., though in some stretches of considerable length the pipe is not covered over 18 in. deep.

Contrary to ordinary practice in pipe laying, the joints on the inside of the pipe were filled with Portland cement. The object of this, according to Mr. Felton, was an attempt to reduce friction by adding to the smoothness of the pipe. He figured that a reduction of 3 ft. in the friction head would pay for the cost of doing the work. In commenting on the result of this experiment, Mr. Felton says: "A careful friction test of the pipe since that time does not show conclusively that the friction was materially reduced, as it was almost exactly what is given in Weston's well-known table for new pipe. This pipe was from one to three years old at the time of the test, but other friction tables give much lower friction rates than Weston's." Air valves were placed at all the summits, there being about twenty-two on the line. Instead of automatic air valves, regular 1¼-in. corporations and open-way valves were used, with a pipe running up nearly to the surface of the ground and a gate box at the top.

In laying the pipe a special wagon designed by Mr. Horace Kingman, superintendent of water works, was used. In the trench with the force main was laid a six-wire lead cable for the telephone service and the Winslow recording apparatus used on the standpipe. This cable was placed in 1½-in. wrought-iron pipe, most of which was old pipe secured from a junk man.

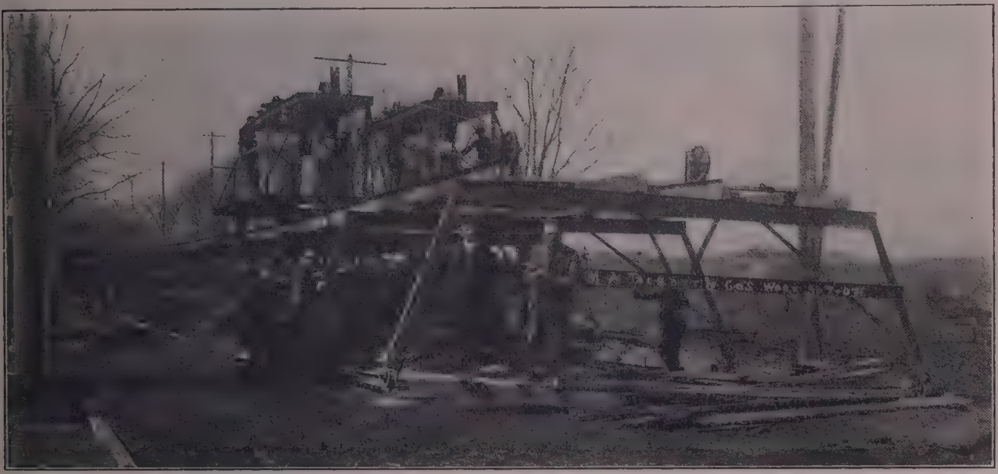
Several tests were made to determine the leakage in the force main. In one instance when 25,810 ft. was tested, the leakage for the first 2¼ days amounted to 100 gal. per day per mile. For the next succeeding 1¾ days, the leakage was 82 gal.; for the next succeeding 4 days, it was 58 gal.; for the next succeeding 13 days, it was 32 gal.; and for the last 50 days, it was only 20 gal. per day per mile. The noticeable decrease may have been due to the stopping of minute leaks, or possibly to the compression or expulsion of air in the summits. A test on the whole line after the pump had been in operation about a year, indicated a leakage of 285 gal. per day per mile, under an average pressure of 71 lb.

The Brockton water supply system was designed by Mr. Charles R. Felton, City Engineer, and the construction, with the exception of the brick chimney and standpipe, was done under the supervision of Mr. Horace Kingman, superintendent of water works. Owing to a strong local feeling this construction work was done almost entirely by city labor, the men being paid $2.2 per day of eight hours.

The Sayre Colliery Equipment is considered the best yet constructed by the Lehigh Valley Coal Co. The shaft of this colliery is 589 ft. deep, and from it two tunnels are now driven, and at a later date it is expected that others will be driven. The underground haulage is to be done entirely by heavy electric locomotives. From the self-dumping cages of the shaft, the coal is carried to the breaker by a bucket conveyor running at a speed of over 100 ft. a minute. The breaker has a capacity of 2,000 tons a day and over 1,400,0000 ft. of lumber was used in its construction. A special feature of it has been the equipment for transmitting power, which is done entirely by ropes. All the shafting is carried on concrete foundations.

Notes on the Baltimore Sewerage Work.

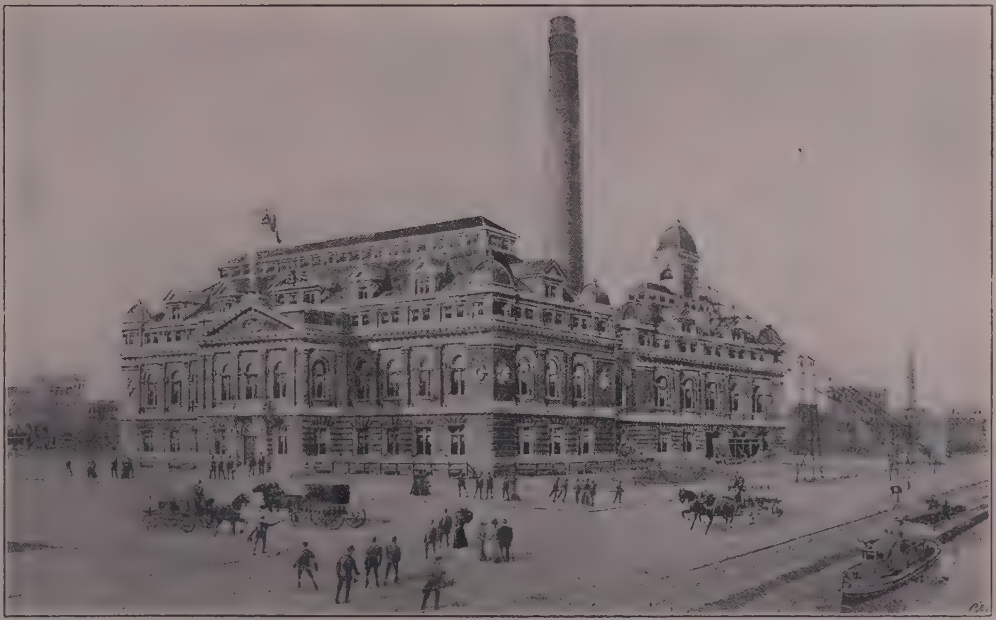
The progress that has been made on the Baltimore sewerage construction since deciding on the method of disposal, on June 1, 1906, has been very gratifying to those in charge of the work. It has been possible to place under contract or to advertise about $3,000,000 worth of construction, and in a short time it is expected to add half a million dollars more to this total. The rapid rate with which this great undertaking is being placed under contract is a matter of surprise to those engineers and public officials who are acquainted with the long periods of indecision and delay during the discussions of the subject in the past. It was generally felt that the work would probably drag, but under the direction of the chief engineer, Mr. Calvin W. Hendrick it is progressing at a rapid rate.



Trench Machine Used on the 12-Foot Concrete Outfall Sewer, Baltimore.

In the work on the outfall sewer, which has a 12-ft. section built of reinforced concrete, the contractors, M. A. Talbott & Co., are using a trench machine, which consists of an iron framework resting on 8x10-in. timbers 28 ft. long, which span the trench as shown in the accompanying illustration. The framework is 23 ft. wide from outside to outside and 290 ft. long over all, including the engine house at one end, and carries a double track on top which is 9 ft. above the surface of the street. On each side of the track there is a carrier, each with two buckets. These carriers are moved along the tracks and the buckets are raised and lowered by means of wire cables operated by two Lidgerwood double-cylinder double friction drum hoisting engines, one of 20 h.-p. and one of 30 h.-p. The larger engine operates two buckets of 1 cu. yd. capacity each, and the other operates two ¾-yd. buckets. The two buckets on each carrier are raised and lowered simultaneously. The full buckets are raised out of the trench and conveyed to the end of the machine farthest from the engines, where they are emptied into wagons which haul away the earth. Later on it will be deposited over the completed sewer. The net length of the conveyor which can be operated is 240 ft. Its total length without the engine house is 272 ft. The engine house is 18 ft. long; the gauge of the lower tracks is 22½ ft. and of the two upper tracks 5½ ft.

One of the most interesting portions of the sewerage system is the large pumping station. The contract for the pumping engines have already been placed with the Bethlehem Steel Works, but at this writing the Commission has not yet finally adopted any general plan for the building itself. The accompanying illustration shows one of the sketches made by Mr. Henry Brauns, the architect, for the exterior treatment of the station. Some members of the Commission do not believe it will be advisable to build such an ornate structure, and for this reason it has not yet been determined whether this design will be adopted. It is of much interest, however, as showing what can be done in the way of architectural treatment for a building of this sort. The engine house will be 61x187 ft. and 70 ft. high from basement to roof plate, and will contain five pumping engines, each with a capacity of 27,500,000 gal. per day. There will also be a screen chamber building 26 ft. x 154 ft. and a 52 x99-ft. boiler house. The materials suggested for this building are a granite base, brick walls above the surface, terra cotta cornices and a slate roof. In the design of this structure Mr. Brauns was able to draw on a wide experience in planning pumping stations and power buildings in various parts of the country, and has manifestly succeeded in obtaining a design for the exterior which is at the same time attractive and appropriate.



Study for the New Sewage Pumping Plant at Baltimore.

A Definition of Reinforced Concrete was given by the English Court of Appeals recently in the case of Mouchel versus Coignet. This definition reads as follows: "Strengthened concrete may be shortly described as concrete strengthened by the incorporation in it of rods, so arranged as to supply the power of resisting tension strains, a power possessed in a marked degree by iron, but hardly at all by concrete, which, on the other hand, possesses great power to resist compression strain."

The Purchase of Coal by Specification by the Government.

Some years ago the United States Treasury Department put into effect a system of purchasing coal upon the heat-unit basis for the electric plants under its charge, the quality of the coal under such a contract being determined by proximate analysis and calorimetric tests. This step was taken at the suggestion of Mr. J. Woodwell, inspector of electric light plants in the Department. Since the work was first started, the method has been developed, step by step, as the result of experience in its use in the Department and also by studying similar methods employed by the Interborough Rapid Transit Co. of New York, the Fuel Engineering Co. of Chicago, the United Gas Improvement Co. of Philadelphia and other corporations which buy large amounts of coal. The success of the system has been so marked that this year Congress authorized the Fuel Testing Division of the Geological Survey to determine the quality of coal purchased by all Government Departments, the expense being borne by the general appropriation for fuel testing. It was accordingly considered opportune to prepare a general specification for all coal offered for Government use, except certain purchases made for the Navy. A standard specification was developed by the joint efforts of Messrs. Woodwell, E. D. Randall of the Geological Survey, and Mr. S. S. Voorhees, engineer of tests, Treasury Department. The preliminary draft of this specification was submitted to the Advisory Board on Testing Materials, appointed by President Roosevelt some time ago, and this board modified the arrangement of the specifications somewhat. It seems likely that at least a half of the departments of the Government will adopt the specifications during the coming fiscal year. The gentlemen who have prepared them do not claim that they are perfect, but believe that they are fair to both purchaser and seller of coal, and afford as fair a means of making such purchases as anything that has been suggested as yet. The purpose of calling attention to these specifications at this time is to bring out any criticisms of them which the readers of The Engineering Record have to offer. Many coal dealers have already signified their willingness to furnish fuel on this basis, and have commended the method.

What was desired in the preparation of these specifications was not necessarily the cheapest

Deductions Made from Standard Tender Price of Coal for Excess Ash.

Percentage of Ash Specified.	Maximum Percentage of Ash Not Penalized.	2	4	7	12	18	25	35	Maximum Limit of Ash.
		Deductions, in cents per ton. Percentages of ash in dry coal.							
5	7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	12
6	8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	13
7	9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	14
8	10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	14
9	11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	15
10	12	12-13	13-14	14-15	15-16	16-17	17-18	....	16
11	13	13-14	14-15	15-16	16-17	17-18	18-19	....	16
12	14	14-15	15-16	16-17	17-18	18-19	19-20	....	17
13	15	15-16	16-17	17-18	18-19	19-20	20-21	....	18
14	16	16-17	17-18	18-19	19-20	20-21	21-22	....	19
15	17	17-18	18-19	19-20	20-21	21-22	....	....	19
16	18	18-19	19-20	20-21	21-22	22-23	....	....	20
17	19	19-20	20-21	21-22	22-23	....	....	....	21
18	20	20-21	21-22	22-23	....	....	....	....	22

or highest grade of coal per se, but the coal which will insure the greatest net economy in plant operation. Accordingly the specifications open with a description of the fuel desired for the contract in hand, inserted by the Government representative, based on a consideration of the boiler and furnace conditions under which the fuel will be used. It is not expected that all deliveries will be absolutely uniform or agree exactly with the standard established by the contractor in his tender under the specification, but it is necessary for all deliveries to be within the limit set by the Government. These limits are considered wide enough to permit the use of the output of any mine or group or mines, provided proper care is exercised in mining and in picking out refuse. Bearing these facts in mind it is only necessary for the bidder to select coal for each proposal which will meet the description given in the specifications for that particular lot, and permit deliveries within the time limit set. Of course the standard established by the contractor should be one which requires the least correction for variation in heat units and ash from the values set up.

In all practicable cases the coal will be sampled at the time it is being delivered into the building where it will be used. The sample taken will in no case be less than 100 lb., selected proportionally from lumps and fine coal. It will be pulverized as rapidly as possible until none of the fragments exceed ½ in. in diameter, and will then be quartered until the final sample can be contained in the shipping can or jar, which will be sealed air-tight and sent to the Treasury Department for analysis. Immediately on receipt of the sample it will be analyzed according to the method adopted by the American Chemical Society.

Coal containing percentages of volatile matter, sulphur and dust higher than the limits indicated in the specifications and coal containing a percentage of ash in excess of the maximum limit indicated in the accompanying table will be rejected. Occasionally deliveries containing ash up to the percentage indicated in the column of "Maximum Limits for Ash" in the table, may be accepted. Frequent or continued failure to maintain the standard established by the contractor accompanying the bid, will be considered sufficient cause for the cancellation of the contract. Payment will be made on the basis of the price named in the proposal for the coal specified by the bidder, corrected for variation in heating value and ash, as shown by analysis, above and below the standard established by the bid. For example, if the coal contains two per cent. more or less, B.t.u. than the established standard, the price will be increased or decreased two per cent., accordingly. The price will also be further corrected for the percentages of ash. For all coal which by analysis contains less ash than that established in the proposal of the bidder a premium of one per cent. per ton for each whole per cent. less ash will be paid. An increase in the ash content of two per cent. over the standard established by the contractor will be tolerated without exacting a penalty for such excess. When the excess exceeds two per cent. above the standard established, deduction will be made from the price in accordance with the accompanying table.

The heating value expressed in B.t.u. of coal containing approximately the same percentage of ash is essentially a direct measure of the actual value to the purchaser, and for this reason the specification provides for an adjustment of payment in direct proportion to the variation in heat units in the coal as received. As the coal is weighed when delivered and the payments are based also upon the price per ton, it is necessary to determine the heating value of the coal in the condition in which it is received, containing whatever moisture may be present at the time. The further correction in payment made for the variation of ash in dry coal is to take account of the cost of handling additional fuel and ash and its effect on the capacity of the boiler and furnace.

Tar on Macadam and Clay Roads.

Macadam and clay roads are said to have been successfully treated with unrefined gas tar at South Haven, Mich. The macadam street on which the experiment was tried had been newly surfaced with limestone macadam upon which no travel had been permitted and which was allowed to dry ten days before the tar was applied. The tar was heated in a 150-gal. roofer's tar kettle and was spread with 14-quart sprinkling cans made by fitting to an ordinary garden sprinkler a special spout which, when the can was in use, gave a horizontal opening about 6 in. long and ⅛ in. wide.

The kettle was set up in the middle of the block to be treated and two barrels of tar were put in it and brought to the boiling point. Six sprinklers were then filled, two of which were carried by each of three men. Each man poured with a sweeping motion from side to side and covered about one-third of the width of the 50-ft. macadamized surface, thus carrying a straight face of tar up the street. Closely following the sprinklers was a man with a fibre broom who smoothed out the thick spots and rubbed the tar in wherever dust or depressions prevented a good contact. Immediately following came two men, who with scoops covered the tar with a ½ to ¾-in. layer of limestone screenings. After this the street was rolled at once with a 10-ton steam roller, after which it was opened to traffic.

The results of this work, according to Mr. C. R. Wightman, city engineer of South Haven, from whose account as given in the report of the State Highway Commissioner of Michigan these notes have been taken, are that the street is free from dust and that it dries very quickly after a rain. It has also been noticed that snow melts and runs off much faster than it does on brick streets and that a few hours' thaw clears the street so that there is nothing to freeze when night and a lower temperature comes.

The gang which did the work was organized as follows: One kettleman, who acted as foreman, at 22½ cents per hour; two barrelmen, at 22½ cents; three spreaders, at 22½ cents; one broomer, at 17½ cents; two surfacemen, at 17½ cents; one team hauling tar, wood and screenings and moving the kettle, at $3.50 per day of ten hours. The cost of treating 16,620 sq. yd. of old street was as follows: 7,750 gal. of tar, at 3 cents, $232.50; labor, $247.86; 292 cu. yd. of screenings at 90 cents, $262.80; total, $743.16, or nearly 4½ cents per square yard. The cost per square yard for labor was 1½ cents and the quantities of material required per square yard were: Tar, 0.466 gal.; screenings, 0.175 cu. yd. These costs include the cleaning of the street surface which was done with steel brooms and hoes. In addition the city roller was used about fifteen hours. With a portable kettle Mr. Wightman believes that a saving of 20 per cent. would have been effected by doing away with the time lost by all hands when the fire was put out and the tar drawn off and the kettle moved.

On about 1,000 sq. yd. of street torpedo sand was used instead of limestone screenings. The results were not as satisfactory as where screenings were used as it was difficult to make the sand dry enough to take up the tar properly. It is believed that if good sharp torpedo sand, free from moisture, could be obtained the results would be satisfactory.

The effect of the tar on macadam streets was so pleasing that it was decided to experiment on clay. Accordingly, a porous yellow clay street, having a width of 40 ft. between wood curbs, was shaped up with a road grader, making a crown of about 20 in., and rolled with the 10-ton steam roller. Tar and screenings were applied in the same manner as on the macadam streets, and the results, according to Mr. Wightman, have been surprisingly good. In two or three places where light uncompacted dust was on the surface, the tar and stone covering has been broken, but otherwise it is in good condition, shedding the water nicely, and bids fair to be a good hard road for some time. The cost of the tar and stone was practically the same as on macadam. Before applying the tar the road should be shaped and carefully smoothed by rolling and wetting until no loose or dry powdered clay remains; and, just the reverse from macadam which must be perfectly dry, the clay should be slightly moist, as the hot tar on dry, powdered clay rolls up into minute balls and does not spread out as it should in a film or sheet. In every instance, the tar should be as near the boiling point as possible, when applied to the street.

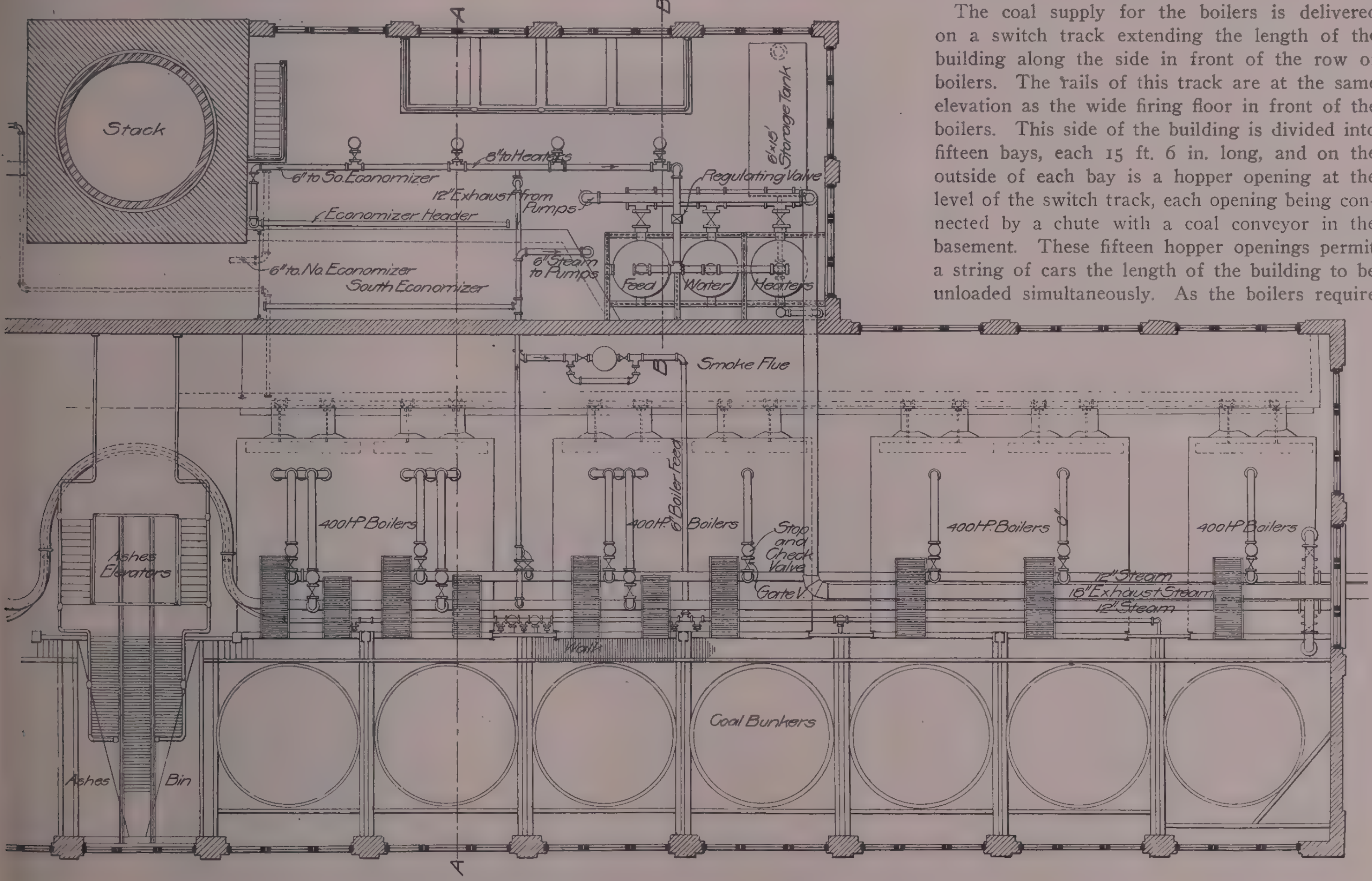
The unrefined tar which was used on this work is a very active irritant and will draw a blister in short order. In order to obviate this, men handling tar should keep their hands and faces well smeared with fresh lard.

A Gravel Screening Device with which gravel can be taken from a pit with a drag or scoop scraper and delivered into a wagon without the use of a shovel, being screened at the same time, is described in the report of the State Highway Commissioner of Michigan. The device consists of an inclined slide-way about 8 ft. high, made of four smooth wooden rails, two being placed so as to support the scraper and two acting as guide rails, one on each side. On each side of the scraper a small wheel is attached which runs on the outside rail of the slide-way. Near the top of the slide, the two inside rails turn sharply downward, thus allowing the scraper to pitch forward, pivoting on the supporting wheels, and allowing the gravel to slide off upon a slanting screen consisting of bars of ⅛x1-in. steel placed on edge and spaced as desired. The wagon is placed under the lower edge of the screen so that the gravel sliding from the latter will fall into the wagon box. The scraper is filled in the pit and drawn up the slide by horse power, the towing rope being long enough to pass from the scraper through a pulley at the top of the slide and thence to the horse. The operations of filling and drawing the scraper up the slide do not mutually interfere.

The North Boiler House of Swift & Co. in the Union Stock Yards, Chicago.

The north boiler house of Swift & Co. in the Union Stock Yards, Chicago, has a capacity of 5,600 h.-p., made up of fourteen 400-h.-p. water-tube boilers. This boiler house is one of four, with a combined capacity of 14,800 h.-p., which supply steam for power and for various other purposes to the packing and manufacturing plants of Swift & Co. in the yards. These plants cover an area of 43 acres, which is all quite closely built up with buildings ranging from one to ten stories in height. Owing to the many and varied requirements for power and for live and exhaust steam at widely separated points, a central station supplying steam to all of the plants could not be operated economically. The boilers are operated 24 hr. a day during six days in the week, the maximum demands for steam occurring at different periods in the 24 hr. Approximately 40 per cent. of the total steam power required in boilers is utilized for cooking, heating and cleaning in the slaughtering and packing plants, the cooking being done largely in sealed tanks at pressures varying from 2 to 40 lb. The refrigerating machines used in the packing plants have a combined capacity equivalent to 2,350 tons of ice per 24 hr. and consume a considerable portion of the balance of the power generated. The remainder of the boiler capacity is utilized to a large extent in supplying steam to engines driving electrical generating units, the power from the latter being used for lighting and by motors in different places around the plants.

The New Swift Boiler House.



Half-Plan of Boiler House and Plan of Pump and Heater Room.

The north boiler house was the second step in a plan to concentrate the entire boiler equipment of all the Swift & Co. plants in the yards in three boiler houses located at the corners of a nearly equilateral triangle. The first one of these houses has been built for some time and contains sixteen 400-h.-p., water-tube boilers. It adjoins a central electrical power station containing five generators, with a combined capacity of 3,700 kw. The third boiler house of the new scheme is to be built during the coming season and is to contain twelve 400-h.-p. water-tube boilers. This new house will replace the third one of the four now in service; the present fourth boiler house contains four 400-h.-p., water-tube boilers, and is a part of the original power station of the packing plant.

The present four boiler houses are all interconnected by steam lines from which the demands for steam for power and for direct use in the slaughtering and packing plants are supplied. A considerable proportion of the steam-consuming units are run non-condensing, the exhausts from these units being connected with an 18-in. main, which joins all four boiler houses together and radiates to different parts of the plants, with a total length of nearly 4,000 ft. This exhaust main carries steam at a pressure of from 2 to 4 lb., which it supplies for heating the feed water in the various boiler houses and for cleaning, sterilizing and other similar work in the slaughtering and packing plants.

The north boiler house is at one end of a branch of this long exhaust main and of branches of the steam supply mains. It is a fireproof structure of brick and concrete, with a flat reinforced-concrete slab roof carried by steel trusses resting on the side walls. The building is 52 ft. 10 in. by 236 ft. in plan and 64 ft. in height from the basement floor to the roof line. The interior of the building is in one large room containing the boilers, all fourteen of which are in a single row with seven on each side of the transverse center line of the room. Over the firing floor of the boilers is a row of elevated coal bunkers, one of which is provided for each boiler. The economizers, feed-water heaters, pumps and so forth are in two smaller rooms at the rear of the building, one on each side of the stack which serves the boilers.

The coal supply for the boilers is delivered on a switch track extending the length of the building along the side in front of the row of boilers. The rails of this track are at the same elevation as the wide firing floor in front of the boilers. This side of the building is divided into fifteen bays, each 15 ft. 6 in. long, and on the outside of each bay is a hopper opening at the level of the switch track, each opening being connected by a chute with a coal conveyor in the basement. These fifteen hopper openings permit a string of cars the length of the building to be unloaded simultaneously. As the boilers require 300 to 350 tons of coal every 24 hr., this is a particularly great advantage in that all of the cars can be unloaded during the day, and cars do not have to be moved after they have been placed. For the present the railroads handling the coal used under these boilers have few side or bottom-dump cars, so most of the coal has to be shoveled over the sides of the cars into the hoppers by hand. If these railroads acquire equipments of side or bottom-dump cars, the space is available to build track hoppers in which such cars may be dumped, but even with such an arrangement much of the coal is frozen in the cars when delivered in the winter and has to be picked and shoveled by hand.

The conveyor into which the coal is discharged from the hoppers along the track is an endless link-belt overlapping bucket carrier, extending the full length of the basement, close to the side wall of the latter, then vertically up at the end of the building to a horizontal run just under the roof, back to the other end of the building and down to the basement again. The coal only is handled by this conveyor, an entirely separate system of ash handling being installed. The upper horizontal run of the conveyor is provided with a traveling automatic tripping device which runs on rails under the conveyor and causes the coal to be dumped from the latter into the inclined chute leading to any bunker desired. This conveyor has a capacity of 60 tons an hour and was built by the Link Belt Co., of Chicago.

The elevated bunkers are steel-plate cylinders with a cone-shape bottom and have a capacity of 60 tons each when level full. They are carried by a steel frame supported by columns in the outside wall of the building and by columns in the fronts of the boiler settings, so the firing floor is entirely clear. A separate bunker was provided for each boiler, because in the past considerable difficulty has been experienced with fire in the coal from spontaneous combustion in continuous bunkers in other plants of the company. In case a fire occurs in one of the separate bunkers, the coal can be drawn from it without interfering with the other bunkers.

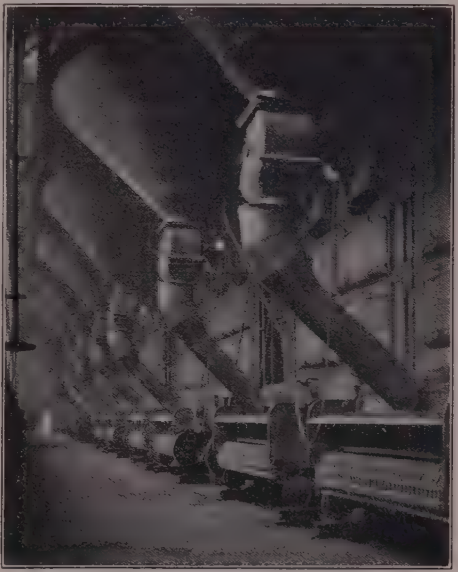
The flow from each bunker is controlled by a special under-cut gate which is operated from the firing floor by a chain. These gates can be opened and closed easily with one hand, as they are counterbalanced and the chute leading from the bunker to the supply hopper of the chain grate stoker under the boiler is kept free of coal.

In case the coal conveyor breaks down at any time coal can be shoveled from the cars through doors in the side of the building directly on the firing floor in front of the boilers. The bays into which the side wall of the building is divided are each fitted with a large steel door carrying considerable window space. These doors can be opened and as the top of the cars on the track is level with the bottom of the door opening the shoveling can be done readily. The windows in these doors and windows above the latter make the front of the boilers particularly well lighted and afford good ventilation for the boiler room.

The fourteen 400-h.-p., water-tube boilers are of the Babcock & Wilcox type and are each fitted with a Babcock & Wilcox automatic chain-grate stoker. Instead of the rails of the track on which the wheels of these stokers are set being placed flush with the floor, they are raised about 8 in. above the latter and are pitched downward 1 in. from the back to the front. The two rear wheels of each stoker were turned down 2 in. smaller than the front wheels to keep the grates level. With this arrangement any stoker can be pulled out on the firing floor with comparative ease when it is to be repaired or when the boilers are to be washed, a portable track being laid on the firing floor to carry the grate. The fine coal and ashes which fall through the stokers are caught on the tight concrete floor under the latter and are raked out in front and shoveled into the supply hopper of the grate from time to time. A slight depression is formed in this floor so the material falling on it may be quenched if necessary. Removing the small amount of fine coal and ashes that falls on this floor has not been found to interfere with the regular duties of the fireman, and at the same time, the small quantity of poor fuel is readily passed into each boiler furnace when the fire is good, without noticeably affecting the efficiency of the latter.

The floor under the chain grate extends back to within 20 in. of a wall carrying the boiler arch, an opening of that width being left across the furnaces setting between this floor and that wall. The ashes are discharged from the chain grate through this opening into a special dump car on a track in a compartment immediately under the floor of the grate chamber. These openings at the rear end of the furnaces are not closed in any manner, but are each fitted with a hopper which reduces the opening very materially. The rear end of the chain grate is extended back to within 4 in. of the bridge wall and a water back is placed on the latter which further reduces the width of the opening to 3½ in., so the possibility of air leakage through the ash openings is small. Air leakage through this rear opening from under the front of the chain grate is prevented largely by a brick arch built up under the lower horizontal run of the grate and by a vertical plate between the upper and lower horizontal runs.

The tracks on which the special dump cars are normally placed in the compartments under the ash openings of the different furnaces are on a slight grade and connect with a track which extends the length of the building immediately under the firing room floor. This track is on a grade from both ends of the building toward the center of the latter where there is a turntable connecting with a short track at right angles to it, that leads to a freight elevator of the usual type. This elevator has a capacity of 7,000 lb. and is operated by a steam engine on a platform well above the top of the boilers. The elevator travels up to a platform built over an ash storage bin above the firing floor and between the two middle coal bunkers. This storage bin has a capacity of nearly a car and a half, the boiler furnaces producing on the average two cars every 24 hr. The ashes are discharged from it through a spout in the side of the building into a car on the switch track, or can be discharged over the cars on the ground and then hauled away by teams for filling.



The Firing Room Floor.

The cars of ashes are brought up from the basement on the elevator and are run out on a track on the platform over the ashes storage bin. These cars have a capacity of about 50 cu. ft., and when loaded are easily pushed along the graded tracks in the basement by two men. They each have a rigid frame on a four-wheel truck and a water-tight body built of steel plates. The bodies are triangular in cross-section and are supported at each end on a rocker arm, the arms being riveted firmly to plates of the body of the car. Each arm rocks on a channel of the car frame, the car body being built so it will tip forward on these arms and discharge its contents, unless it is held in an upright position by a latch on the frame. The ends of the rails on the platform over the storage bin extend out to the edge of the platform and are turned up to prevent the car running too far. When the car is dumped, the truck frame is anchored to the platform by two links which prevent it from overturning.

With this ash-handling equipment two men readily take care of the ashes from the fourteen boilers when the latter are being pushed to 15 to 20 per cent. overload. At the same time, the coal conveyor is entirely relieved of ash handling duty. As a large percentage of the repair charges on bucket conveyors in plants where ashes and coal are both handled by the conveyors is due to the wear brought about by the acids and grit in the ashes, this saving is alone considerable. On the other hand, the conveyor is always available for delivering coal to bunkers and the cost of handling ashes in the manner described has been found in this plant to be at least no more expensive than if done in connection with a coal conveyor.

If the elevator is out of service at any time the ashes can be shoveled from the compartments under the furnaces into the horizontal run of the conveyor in the basement and taken up and dumped into the elevated storage bin. One end of the longitudinal track in the basement under the firing floor extends out of the building on an incline leading to the surface so the ash cars may also be hauled out and dumped, if necessary.

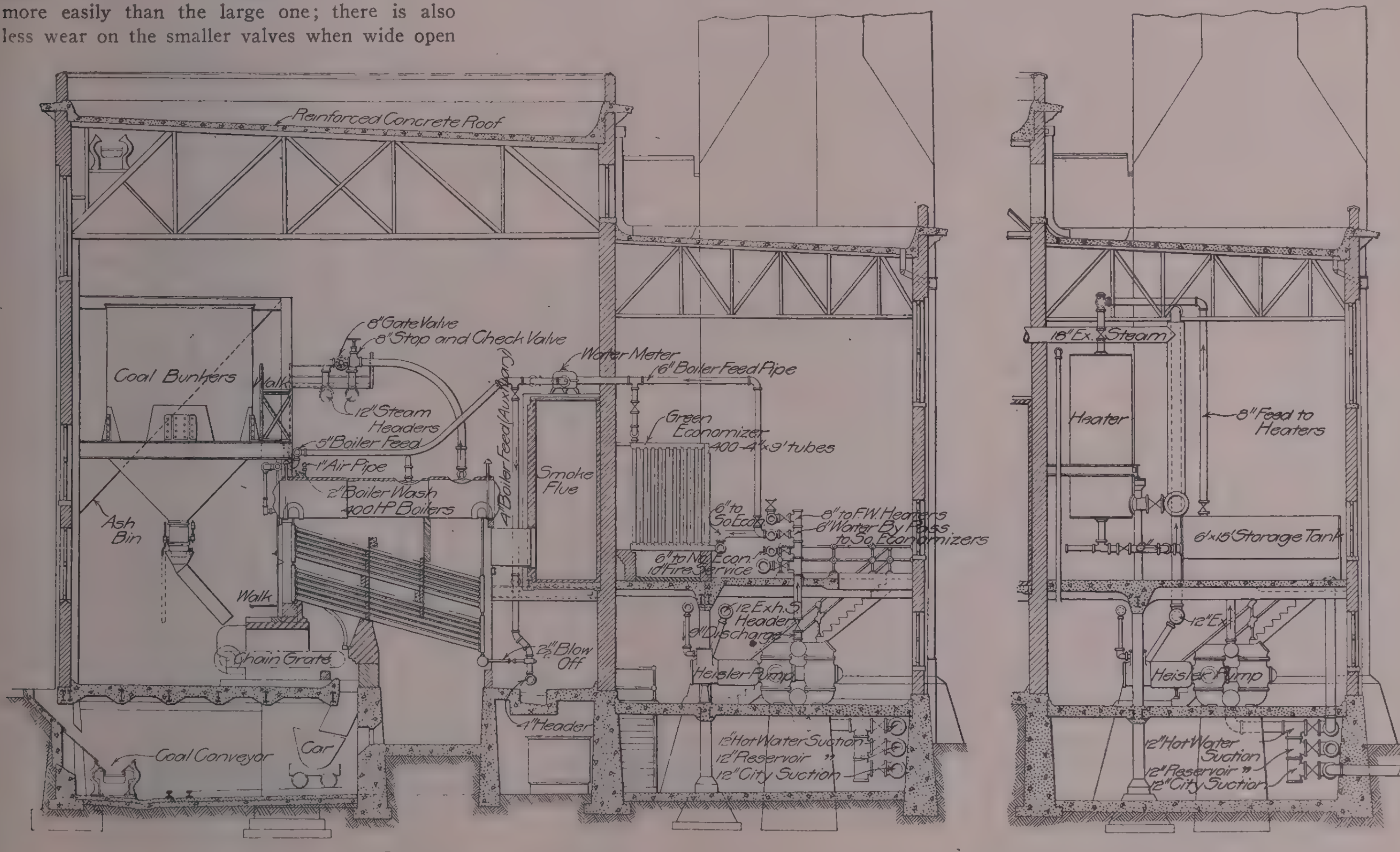
In order to avoid any difficulty from failure of the attendants to quench the ashes in the cars while the latter are standing under the openings at the rear end of the grates, a special automatic system of sprinkling has been installed for each set of seven boilers. A steel tank, 3 ft. in diameter and 4 ft. high, with a capacity of 90 gal., is provided for each system and is placed over the firing floor and between two of the coal bunkers. This tank is fed from the water mains, its contents being discharged automatically by a timed device similar to that used in toilet room plumbing fixtures. A perforated pipe is suspended over each ash car and the water is sprayed on the ashes through these pipes. The bodies of the ash cars being water-tight, no water drips from them while they are in transit to the ash storage bin.

The brick stack which serves the boilers is 14 ft. in diameter inside and 225 ft. in height. It is built on a separate concrete footing on piles driven to hardpan. A smoke flue extends along the rear wall of the boiler room 12 ft. above the floor of the latter, and connects through the rear wall of the building with the stack, each boiler being connected with it by a short straight breeching. This flue is 5 ft. 9 in. wide and varies in height from 17 ft. at the connection with the stack to 7 ft. at each end of the boiler room. It is lined with fire-brick, the rear side being against the wall of the building and the top and bottom being concrete slabs. The flue is carried by steel girders between the boiler settings and the rear building wall.

The water supply for the boiler plant is from two sources, one being Lake Michigan water from the city mains, and the other ground water from six deep wells owned by the company. The Lake Michigan water is used almost entirely for boiler feed purposes, as the deep-well water contains impurities which interfere with the operation of the boilers. The deep-well water is available, however, for boiler washing and other purposes and is drawn from reservoirs built underground.

The south one of the two rooms at the rear of the boiler room is 28 x 58 ft. in plan, and contains, on a floor slightly lower than the floor of the boiler room, four 2,000,000-gal. duplex direct-acting, single-stage Heisler pumps, which are run non-condensing. These pumps have

18x22-in. steam ends and 14x18-in. water ends. Their suctions are cross-connected in a basement under the pump-room floor with three distinct 12-in. supply lines, one from the city mains, one from the deep-well reservoirs and one from a hot-water supply. These pumps supply feed-water to the boilers and furnish water to a system of fire protection mains extending to the packing plant buildings. One of them has sufficient capacity to supply the boilers, but two of them are generally kept in service for this purpose. The steam supply line to each of these pumps is a 4-in. pipe, but a 1½-in. pipe can furnish sufficient steam to operate each of them when they are being used for pumping feed water. A 1½-in. by-pass was therefore placed in each 4-in. line around the valve at the pump controlling the large supply pipe. This by-pass is fitted with a valve so it may be opened or closed. Ordinarily, however, the 4-in. valve is closed and steam is supplied through the by-pass as the latter is more easily controlled and the smaller valves can be taken out and replaced more easily than the large one; there is also less wear on the smaller valves when wide open than on the larger ones when nearly closed, as they would be under usual conditions. At the same time the large supply pipes are always available for fire service requirements.



Cross Section at A-A

Section thro. Pump Room at B-B

Cross-Sections of Boiler House and Pump and Heater Rooms.

The feed water for the boilers is normally passed through three heaters in a room directly over the pump room. These heaters were made in the boiler shops of Swift & Co. in the yards, and are old cooking tanks that had been used in the packing processes. These tanks are 6 ft. in diameter and 15 ft. long and are set vertically, with their bottoms 6 ft. above the floor. A grate was built in each tank, 4 ft. above the bottom; on this grate old granite paving blocks were piled to the top of the tank, which is closed. Water is admitted at the top and steam at one side of the bottom of each tank, the heated water being drawn out through a connection in the middle of the bottom. These heaters have proved to be very satisfactory in service and are particularly valuable in being capable of responding to sudden and heavy demands for water. The steam supplied to them is drawn from a branch of the 18-in. exhaust steam main connected with the four boiler houses, which branch extends through the boiler room into the heater room. The feed water can be raised to 212° Fahr., or higher by the heaters before being delivered to the pumps which supply the boilers.

The hot-water outlet pipes from the three heaters are inter-connected and discharge into a closed 6x15-ft. circular storage tank placed horizontally on the floor of the heater room, the boiler-feed pump normally drawing its supply from this tank. A baffle with its crest 3 ft. above the bottom is placed in the tank about 3 ft. from inlet end of the latter and acts as a weir. A second baffle is suspended from the top of the tank, 3 ft. from the outlet end, with its lower edge 1 ft. below the crest of the weir toward the inlet end. An automatic device maintains the water level between the two baffles about at the level of the weir formed by the baffle at inlet end, so that any oil in the water will rise to the surface and may be blown out through a connection provided for that purpose. This simple manner of separating by gravity the oil in the feed water has been found entirely satisfactory during the year the boiler plant has been in service.

The discharge pipes from the four pumps are carried up into the room in which the heaters are placed, where they each have a separate connection to the headers of four distinct water supply systems, each connection being provided with a valve so any pump may discharge into any header without reference to the other pumps. The four headers are placed horizontally just above the floor level and one above the other. The lower one is a 12-in. connection to a fire-service system; the second is a 6-in. supply line leading to a Green economizer in the room back of the boiler room and on the opposite side of the stack from the heater room; the third is a 6-in. connection leading to a second Green economizer in the heater room, and the fourth is an 8-in. line supplying water to the feed water heaters.

The amount of water supplied to the feed-water heaters through the 8-in. line is regulated by a valve operated by the automatic device in the storage tank. This device consists of a large tight pan mounted in the tank on an arm on a horizontal shaft which extends through the side of the tank. A second arm is fixed at its center to the outer end of this shaft, and to one end of this arm is attached a cable leading up to a lever arm operating the valve on the 8-in. main supplying the heaters; the other end of the arm carries a counterweight. The pan in the tank is kept filled with water by a connection from the mains, and is just submerged, but is prevented from sinking by the counterweight. When the water level in the tank falls, the increased weight of the pan of water when not submerged overcomes the counterweight and drops, thus exerting a pull on the cable which opens wider the valve on the heater inlet connection and restores the water level in the tank. This device has been in use for nearly a year, during which time is has given perfectly satisfactory results, the water level in the tank being maintained at practically the same stage at all times.

The two 6-in. headers leading from the pumps to the two economizers each have a by-pass connection by which the economizers may either one be cut out of service and feed water supplied directly to the boilers. The economizers are also each in a by-pass connection between the stack and the smoke flue in the boiler room, these connections being arranged with dampers so they may be shut off when the economizers are not in use.

The 6-in. boiler-feed supply line for each set of seven boilers leads over the smoke flue and over the top of the boiler settings to a header line extending half the length of the buildiing over the front of the boiler settings. The two drums of each boiler are connected at their front ends to this header line. A 4-in. blow-off header extends the length of each set of seven boilers in the space between the rear of the latter and the smoke flues, and has an auxiliary connection with the 6-in. boiler-feed supply line. This header has 2½-in. blow-off connections with the mud drums of the boilers, so that feed water may be supplied to the boilers through those drums in case the regular supply header or connections are put out of service.

The boilers have to be washed about once a month, owing to the nature of the water supply. Although the plant is operated 24 hr. daily six days a week, the loads on Saturday and Monday are not so heavy as on the other days so the washing can be done on Saturday, Sunday and Monday without interfering with the necessary steam supply. Water for washing is supplied through a 2-in. line laid on the tops of the boiler settings, parallel with the feed-water header. Three connections on this line, fitted with 2-in. quick-opening valves having hose connections, are provided to each set of seven boilers. The wash water is drawn off through the blow-off connections between the mud drums and the 4-in. header along the rear of the boilers, this header discharging into a large tank in the basement in which the scale is settled out and the water used again for washing. A 1¼-in. air supply line also extends along the fronts of the boilers and furnishes air under pressure to operate an air motor used in buffing the boiler plates and headers. The end of the shaft of this motor is fitted with emery cloth with which the buffing is done, the emery cloth being replaceable. The buffing is quickly and readily done in this manner, as the motor is light enough to be handled by one man.

The steam connections from the boilers are designed to provide for the special demands for power which are made on them. Normally, the south seven boilers are operated at 130 lb. pressure and supply steam to a manufacturing plant distinct from Swift & Co.'s plants; the other seven boilers furnish steam at 160-lb. pressure. A 12-in. steam header extends the length of the entire row of fourteen boilers, curving around the shaft for the ash-handling elevator. This header has an 8-in. connection to each of the seven boilers to the north and to three of the seven to the south. A second 12-in. main extends the length of the seven boilers to the south and has an 8-in. connection with each of them. The three boilers having connections to both headers can supply steam to either header separately only, owing to the different pressures in the two headers. In each case where a boiler has two connections, the latter come together in a cast-steel hub just over the boiler setting, so only one opening is required in the drum of the boiler.

Each 8-in. steam connection between the boilers and the steam headers is fitted with a check and stop valve and with a gate valve. The gate valves on all of these connections and, in fact, all gate valves throughout the plant are placed on the side, as this method of placing them has been found in Swift & Co.'s plants to greatly increase the life of these valves.

One of the two 12-in. steam headers leading out of the boiler house is carried overhead directly to the plant which it supplies with power. The other header is carried overhead to connections with the other boiler houses and has branches leading from it to various parts of the packing and manufacturing plants. Owing to the proximity of the ground-water level to the surface during wet weather, underground conduits for these steam lines and for the 18-in. exhaust pipe leading to all parts of the packing plants would have to be provided and could not be built without undue expense. For that reason, the long 18-in. exhaust steam line and all live steam lines connected with the different plants are carried overhead.

The 18-in. exhaust main is built of boiler plates which were assembled in sections, generally 24 ft. in length, and these sections riveted together in the field. In this manner, flange or screw joints were almost entirely avoided, not more than ten such joints being included in the entire length of the main. The latter has no fixed supports at any point, being swung at various places from cables attached to small towers and carried at other points on rollers on towers. It is thus permitted to move with the changes in temperature, but no expansion joints are provided, the bends in the main providing for any movement due to expansion. It follows, for the most part, over the tops of the buildings, all exhaust connections from steam-consuming units being taken into the top of the main, while all connections taking steam from the main are taken out at the bottom, so the condensed steam is always drained from the main. The latter is covered directly with a layer of ½-in. corrugated asbestos over which a 1½-in. thickness of hair felt with a single sheet of prepared roofing felt on the outside. The losses in the main due to condensation are small and are negligible as compared with the ability to supply the demands for low-pressure steam and for heat at different points throughout the plants.

The boiler house was designed and the detail plans for the arrangement of the equipment in it were made in the construction department of Swift & Co. The building was built and the structural steel, coal bunkers, ash bin, and so forth were fabricated and erected by the regular forces of the company in the Union Stock Yards. Mr. H. C. Gardner is manager of the construction department, and Mr. P. J. Slagle is chief engineer for Swift & Co.

A Metric System Bill was rejected on March 2 in the House of Commons.

The Hydro-Electric and Water Power Plant of a Large Paper Mill.

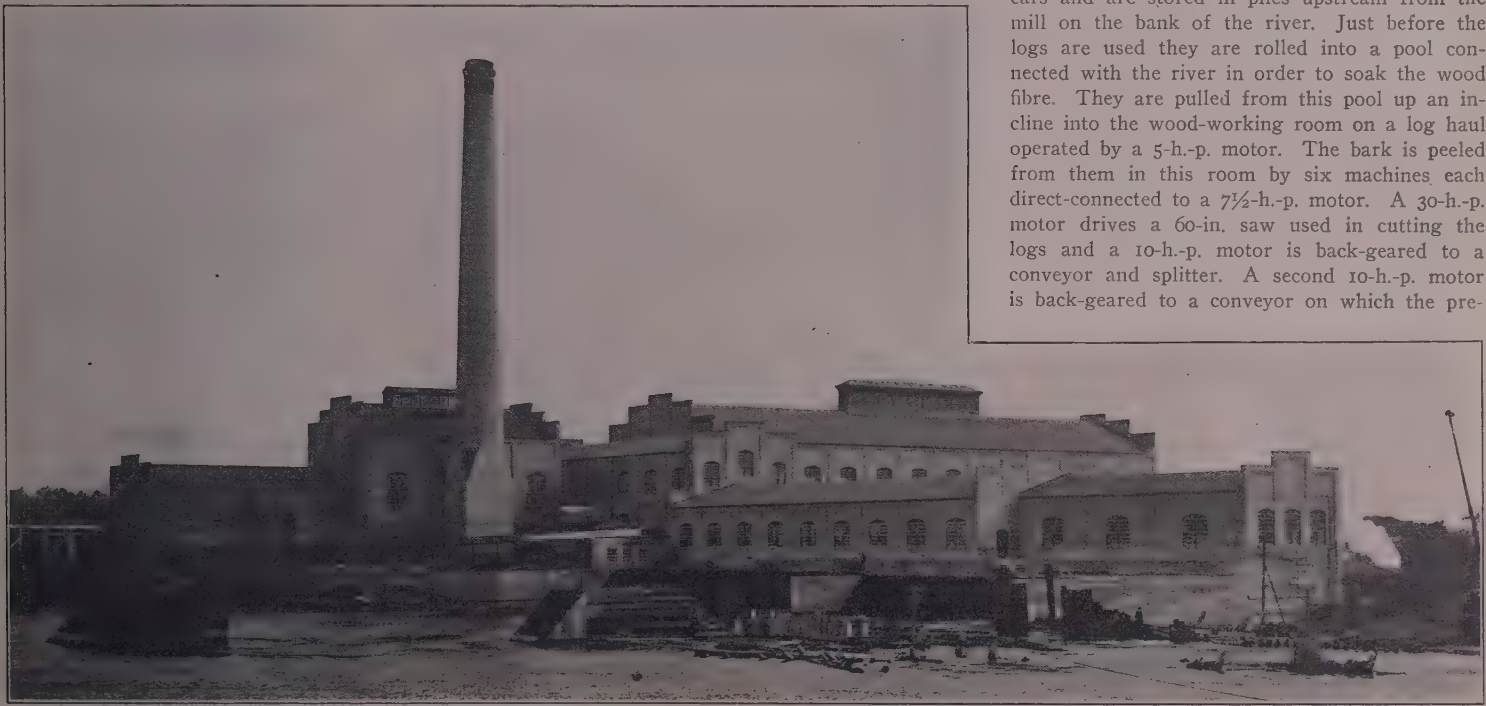
The Watab Pulp & Paper Co. has just completed a large pulp and paper mill on the Mississippi River at Sartell, Minn., 90 miles northwest of St. Paul, which is driven entirely by hydraulic power developed by a dam built across the river at the site. The mill buildings are all of reinforced concrete, the details of their design being made according to the Turner system. They comprise a 36x70-ft. wood-working building, a 58x72-ft. boiler house, a 40x122-ft. beater room building and basement, a 72x230-ft. paper machine room building and basement, a 54x152-ft. wet machine room building, a 32x152-ft. pulp mill, a 20x70-ft. pump room and a 32x72-ft. power house containing the electrical generating equipment. The dam is a rock-filled, timber-crib structure with reinforced concrete abutments at each end.

Driving Steel Sheet Piling on the Face of the Main Dam.

The original bed of the river, which was 600 ft. wide at the site before construction was started, consists of a hard clay soil covered with a layer of gravel. The mill buildings are in a group on one bank of the river, a canal forebay having been built on that side for the waterwheels in the pulp mill and the power house. A 6-ft. concrete breast wall, 225 ft. long, forms a bulkhead for the flumes of these wheels and also the upstream wall of the pulp mill and the power house. These two buildings are at right angles to the river and are on the same longitudinal center line, the outer end of the power house forming one abutment of the dam. Next to that abutment are three sluiceways, each 20 ft. wide, which are equipped with Taintor gates. Beyond these sluiceways is a log sluice, 20 ft. wide; at the other end of the dam are a log sluice 6 ft. wide and a fishway. The remainder of the dam between the two log sluices is a spillway, 216 ft. long, the top of which is 15 ft. above the normal level of water in the tail races of the water-wheels. A slot, 3 in. wide, is cut the length of the crest of the dam and provides for the insertion of 3-in. flash boards, 3 ft. long, producing an available head at the wheels of 18 ft.

The pulp mill contains nine grinding machines each coupled to a shaft carrying two pairs of special 32-in. horiontal Sampson turbines in tandem. Each set of wheels has a separate flume formed by 18-in. reinforced-concrete walls at right angles to and connected with the 6-ft. breast wall of the upstream base of the pulp mill and power house buildings. These flumes are 16 ft. 11 in. apart on centers. The two draft tubes of each set of wheels discharge into the tail race under the floor of the building. The walls of the flumes rest on concrete piers which are built up from the bottom of the tail race and separate the latter into a division for the draft tubes of each set of wheels. The concrete floor of the wheel house and pulp mill is carried by these piers in the tail race.

Three flumes are provided in the power house building and are also formed by 18-in. reinforced-concrete walls joining the 6-ft. breast wall. Their division walls are carried up from the bottom of the tail race and separate the latter into three distinct divisions, one for the draft tubes of the wheels in each flume. The first two of these flumes next to the pulp mill are 24 ft. wide and each contain three pairs of special 32-in. horizontal center-discharge Sampson turbines coupled in tandem to the same shaft. The shaft of each set of these turbines is direct connected through the breast wall on the upstream side of the power house to a 560-kw., 440-volt, three-phase, 60-cycle generator operating at 200 r.p.m. These generators have the same characteristics and are designed to operate in parallel. The third flume of the three for the power house is 26 ft. wide. It contains the turbines of a third 560-kw. unit and a pair of 20-in. horizontal center-discharge Sampson turbines in tandem with a single turbine of the same size and type. The shaft of this set of three turbines is direct-connected to a 70-kw. exciter unit in the power house. The wheels of the main units in the power house are regulated by type B Lombard governors; and the wheels of the exciter unit by hand. The governors are placed on the floor of the generator room and are belted to the shafts of the units.



General View From the River of the Mill Buildings During Construction.

A 250-kw., 240-volt, direct-current generator coupled to a 360-h.-p. synchronous 3-phase, 440-volt motor is installed in the generator room of the power house and furnishes direct current to operate variable speed motors used in driving paper machines in the main building. A 75-kw. motor-driven exciter is included in the power house equipment and supplies excitation for the main units.

The 12 flumes containing the turbines of the pulp mill and power house are protected with an inclined trash rack built of a grill of flat iron bars. A boom will also be placed across the forebay during the logging season to keep logs away from the rack.

The switchboard has 13 panels of blue Vermont marble and is erected along the opposite side of the generator room from the main units. The first panel is for the exciter unit and carries a frequency indicator, a synchroscope, an alternating-current voltmeter and a direct-current voltmeter. Next to this are three generator panels each carrying a direct-current field ammeter, an alternating-current ammeter, a polyphase wattmeter and an oil switch. The fifth and sixth panels are duplicates of these three and are provided for the synchronous motor. The next three are two-circuit feeder panels for the alternating-current motors throughout the mill buildings; these panels each carry an ammeter and an automatic oil circuit-breaker switch. Two direct-current generator panels, each equipped with an ammeter, a recording voltmeter, a three-pole, double-throw switch and a single-pole circuit breaker, are next. This three-pole, double-throw switch is used for starting the motor-generator set from the exciter buses when in the lower position by connecting the equalizer and the negative, thus not requiring the series field to be open when starting. The end two are two-circuit, direct-current feeder panels for the direct-current motors in the paper machine room. The sub-base of these panels contains a resistance switch for starting the direct-current generator of the motor-generator set as a motor. The switches for the two lighting circuits of the buildings are mounted on the sub-base of the alternating-current feeder panels. Current is supplied to these circuits by three 20-kw., 400-200-100-volt transformers with their primaries delta-connected and their secondaries supplying independent three-wire feeders.

Thirteen feeder circuits lead from the board up the rear wall of the power house to a height of 30 ft. in iron conduits and connect there with main cables extending through the mill. Six of the circuits supply 3-phase current to motors with an average of 300 h.-p. to the circuit; two carry direct current with a total of 250 h.-p. to the circuit; two are 100-h.-p., alternating-current circuits and the remainder are the three 20-kw. lighting circuits. The main cables through the mill are anchored by insulated turnbuckles to a channel-iron framework at the end of each run. These frames are supported from the roof trusses and concrete beams of the buildings by a special type of hanger consisting of ordinary No. 0 insulators strung on a 1¼-in. rod threaded through special cast-iron brackets. Each cable lies in the groove of the insulator and the load is carried by the insulated turnbuckles at each end. Each circuit ends in a distributing center consisting of a metal-lined box of suitable size to accommodate the necessary circuits. Each motor circuit is provided with three No-Ark fuse blocks fed from buses of solid 4/0 copper.

The logs used in making pulp are delivered on cars and are stored in piles upstream from the mill on the bank of the river. Just before the logs are used they are rolled into a pool connected with the river in order to soak the wood fibre. They are pulled from this pool up an incline into the wood-working room on a log haul operated by a 5-h.-p. motor. The bark is peeled from them in this room by six machines each direct-connected to a 7½-h.-p. motor. A 30-h.-p. motor drives a 60-in. saw used in cutting the logs and a 10-h.-p. motor is back-geared to a conveyor and splitter. A second 10-h.-p. motor is back-geared to a conveyor on which the prepared wood is delivered to the pulp grinding mill.

The water pressure for the grinders is furnished by a triplex pump which is driven by a 40-h.-p. motor and is located in a pump room at east end of grinder room. The water supply for the mill is drawn from the river through a screened suction pipe by three 6-in. centrifugal pumps each driven by 40-h.-p. motor. The water mains of the mill are all interconnected and are also connected to an Underwriters' fire pump to be used only in case of fire.

As the pulp comes from the grinders it is passed through a sliver screen operated by a 5-h.-p. motor, and drops from this screen into a concrete pulp tank under the floor of the pump room. The pulp is elevated from this tank to flat screens in the wet machine room by centrifugal pumps direct connected to 50-h.-p. motors. These flat screens, of which there are twelve, are in the rear of the wet machines and are driven through friction clutches connected to a line shaft by means of a mitered pinion and core gear, the line shaft being direct coupled to a 100-h.-p. motor. Five wet machines, each direct connected to a 10-h.-p., back-geared motor, are installed.

The deckers are driven from the line shaft belted to the flat screen shaft. The stock drops from them into a decker chest under the beater room and is thence raised to the beaters by a centrifugal pump direct coupled to a 40-h.-p. motor controlled from the beater room.

The beaters are driven electrically, one 50-h.-p. motor located in the basement driving one beater, agitator and jordan; two other beaters are driven by one 100-h.-p. motor. The jordan refining engine is of a new type, being direct coupled to a 150-h.-p. motor mounted on an extension of the jordan base and arranged to slide on rollers as the plug is moved in or out.

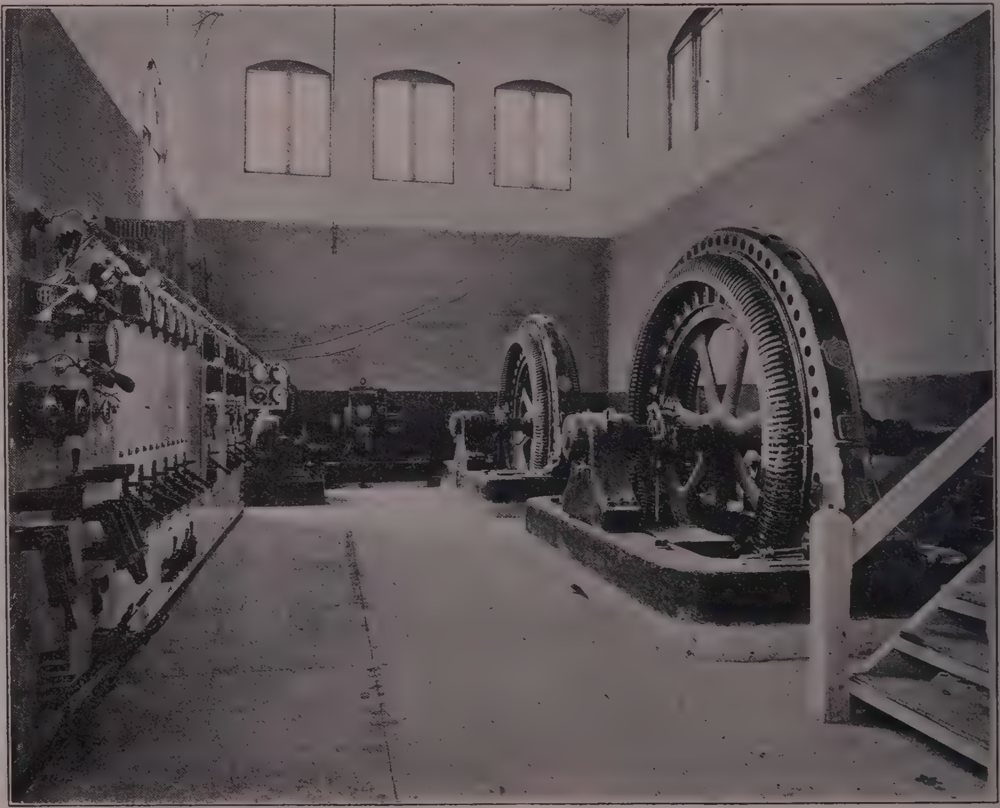
The machine chest is located in the machine room basement. The agitator of this chest, together with the machine screens located on the machine room floor are driven through a short line shaft by a 30-h.-p. motor located in the basement. The machine stock pump for pumping stock from the machine chest to the machine, the suction pump for extracting the water from the sheet of new paper as it passes over the wire of the machine and the fan pump for returning waste water from the wire to the screens are all located in the machine room basement and are controlled from the machine room floor. The necessary shake for the Fourdrineir end of the paper machine is supplied by a 7½-h.-p., direct-current variable speed motor, the amount of shake being varied as the speed of the paper machine is increased. The broke beater for rebeating the broken paper, the stock reclaimer for reclaiming the waste stock under the machine, and the cutters for cutting the odd size rolls into sheets are located in basement of machine room. The paper machine rewinder is driven by a belt with 35-h.-p., direct-current, variable-speed motor also located in the basement.

A 250-h.-p., variable-speed, direct-current motor is direct connected to a 154-in. Beloit paper machine line shaft and operates at 270 to 540 r.p.m., corresponding to 300 to 600 ft. of paper a minute. This speed is varied in such a gradual range that the entire variation may be made without breaking the paper. This system avoids all cone pulleys, slipping belts and so forth and is considered the most convenient and altogether satisfactory method obtainable.

The boiler house contains two 350-h.-p. Stirling water-tube boilers which supply steam for drying paper and for heating the mill. Space is also provided for two additional boilers. These boilers are equipped with Murphy automatic stokers and Dutch ovens, the wood-room refuse being consumed under the boilers. These furnaces are served by an 8-ft. brick stack, 165 ft. high.

The construction of the mill buildings did not involve any unusual difficulties or features, as the footings were all built on the hard clay soil of the site, the excavations generally extending not over 4 ft. below the surface. The concrete in the superstructures was made in the proportions of 1 part Alpena Portland cement, 2 parts sand and 2 parts broken granite, the latter being obtained from a quarry about half a mile from the site. Plain round rods were used throughout for reinforcement in the concrete. The side walls of the buildings are of concrete and no difficulty has been occasioned from water seeping through them. The roofs of the buildings are dressed and matched plank covered with prepared roofing paper laid in tar, and are carried by the side walls and by roof trusses.

The forebay canal and tail race were excavated, the concrete walls of the flumes were built, the turbines were set and the substructure of the pulp mill and power house was completed during the summer while the river was low, so no difficulty was experienced from high water and no cofferdams were required.



The Main Generators and Switchboard

The construction of the dam across the river was the most hazardous part of the whole undertaking. A series of rapids existed in the river at the site of the dam and the water went over these rapids with a great deal of force, even during low stages in the river, while during floods the current was exceedingly swift and violent at the site. The river also has a maximum depth of 30 ft. at the latter during normal stages, which greatly added to the difficulties of the construction. The first work undertaken in building the dam was to construct a rock-filled timber crib across the river on the line of the dam. This crib was built in the water over the designated position and lowered with stone to sink and anchor it, heavy steel cables also being used to prevent it from being washed away. When the crib was finished the water flowed through and over it. The abutment at the power house end of the dam had been completed meanwhile so a cofferdam intended to lay bare about half the width of the river bed next the power house was built on the upstream and downstream sides of the crib of the dam, connecting with the latter at the stream end and with the river bank at the other end.

The upstream side of this cofferdam was a rock-filled timber crib, which was built parallel with the crib of the main dam, 50 ft. from the latter, and joined the main dam 400 ft. off-shore. The downstream side of the cofferdam was built of earth-filled timber cribs. It was also parallel with the crib of the main dam and 50 ft. from the latter, so it and the one upstream formed a cofferdam 100 ft. wide and 400 ft. long. The downstream embankment did not have to be carried to as great a height as the one on the upstream side owing to the difference in the water levels above and below the crib of the main dam. During construction the flow of the stream was all passed around the end of the cofferdam and over the part of the crib for the main dam which was not enclosed by the latter, raising the head against the cofferdam and greatly increasing the current.

After the upstream side of the cofferdam had been completed it was pushed badly out of line by the current. A second rock-filled timber crib was then built within the space enclosed by the first one, but all attempts to seal this second cofferdam with clay and puddle were unsuccessful, as the current would carry away the materials as fast as they could be placed. The decision was therefore made to drive steel sheet piling on the upstream face of the inner crib in order to prevent further undermining and to seal the cofferdam so the water could be lowered in it. Accordingly, 180 tons of the piling made by the United States Steel Piling Company were secured and the driving commenced. The water was 25 to 30 ft. deep for a width of 140 ft. at the end of the cofferdam on the shore side so across this deep place a 30-ft. length of piling was driven first and was followed by a 10-ft. length, in order to secure sufficient penetration in the clay bottom of the river to insure against any possibility of undermining. The alternate piles along the side of the cofferdam were driven 18 in. to 2 ft. deeper than the others to avoid a continuous horizontal joint between the 10-ft. and 30-ft. lengths. After more shallow water was reached 30-ft. lengths were used and were driven to a penetration of 10 to 15 ft.

The piles were all driven with a drop hammer engaged in the leads of a pile driver of the type usually employed in driving wooden piles. A Bern driving cap, which had an oak cushion block and was furnished by the United States Steel Piling Co., was used to prevent battering the heads of the steel piles. On an average thirty 30-ft. piles were driven per day. After the row of steel piles had been driven on the upstream face of the inner crib the seepage through the latter was cut off entirely and no further trouble was occasioned from undermining. A considerable quantity of water came through the crib of the main dam, however, and the water level in the cofferdam could only be kept down by using continuously an 8-in. and three 10-in. centrifugal pumps. While the water level was lowered, a row of vertical wooden sheeting was placed on the upstream face of the crib of the main dam, and the sluiceways and log sluice were built on the latter.

The steel sheet piling had produced such good results that it was decided to drive a row of this piling along the upstream side of the main dam on the outside of the row of wooden sheeting, the latter extending only to the lower edge of the crib of the main dam. The steel piling used in the cofferdam was still in good condition, so all of it, except a few of the 30-ft. lengths which were driven down with the 10-ft. lengths on top of them, was pulled and redriven along the face of the dam. As the length of the dam is considerably greater than that of the cofferdam, and as the latter had to be left intact until the portion of the dam within it had been finished, a considerable quantity of new piles had to be secured for this purpose. All of this row of piling along the face of the main dam was driven to a penetration of 15 to 20 feet in the hard clay of the river bed.

The work of pulling the piles in the cofferdam was done in February last, under as unfavorable conditions as could be imagined. The temperature was as much as 45° below zero Fahrenheit while the piles were being pulled. The puddle, rock and clay through which the piles were driven had been exposed from the inside of the cofferdam and were frozen to a depth of 10 to 12 ft. As the whole cofferdam, the river bank and the crib of the main dam were frozen, the use of dynamite to loosen the piles might have injured the mill buildings. A steam jet was therefore arranged to thaw the earth around the piles before pulling the latter. A pipe line was laid from the boiler house to the point of operations and supplied live steam to this jet. Two single and two double blocks were rove with a wire cable and were swung from the leads of the pile driver for use in pulling the steel piles. Although the latter could be pulled by the hoisting engine of the pile driver with these blocks, after the ground had been thawed around the piles, two triple blocks were later substituted and the pulling progressed more rapidly after that, 18 to 20 pieces of piling being pulled each day. The steam jet was found to be satisfactory in thawing the ground, but the latter was not opened for more than 4 ft. ahead of the pulling work.

Water-Wheels in Position in the Power House and Pulp Mill.

When the steel piling had been driven along the upstream face of the portion of the main dam within the cofferdam, enough of the latter was removed so the river could be diverted through the sluice gates and log sluice at the power house end of the dam. The water level above the dam was lowered then enough so the balance of the crib of the main dam could be completed and the steel sheet piling on its upstream side driven without a cofferdam.

The plans and specifications for the electrical installation were prepared by Mr. Samuel E. Holmes, paper mill electrical engineer, of St. Cloud, Minn., who also had immediate supervision of the work in the field. The construction work was done under the direction of Mr. Charles G. Oberly, superintendent for the Watab Pulp & Paper Co. The electrical equipment was furnished by the Allis-Chalmers Co., of Milwaukee, Wis. The water-wheels were supplied by James Leffel & Co., of Springfield, Ohio.

An Engine Erection Record.

An engine erection record which deserves notice was accomplished some time ago by men from the Allis-Chalmers works, who had charge of installing the second one of a pair of large rolling mill engines at the Edgar Thompson Steel Works. These engines are probably the most massive ever built for such service; they have 50 and 78-in. cylinders, a 60-in. stroke, and a frame and slide cast in a single piece weighing 104 tons, which was illustrated in this journal some months ago. When the time came for installing this engine, the conditions were such that it was necessary to shut down the mills before the work could begin, although the foundations had already been prepared, and every effort was made to be expeditious. The engine was installed within ten days from the time the work began, notwithstanding the fact that the old engine had to be torn out before the new one could be put in place. After the installation was completed, within 30 minutes after steam was first let into the cylinders, the engine was put into service and given its full load driving the rail mill.

Instructions for Reinforced Concrete Field Work.

An unusually complete handbook of instructions for superintendents and inspectors engaged on reinforced concrete construction has been prepared by the Engineering Department of the Trussed Concrete Steel Co., of Detroit. This book is copyrighted, and the following extracts from it are reprinted by permission of the company.

Falsework.—All form boxes must be true, rigid and temporarily braced to withstand handling and erection. They should be carefully re-examined just before placing concrete. In erecting formwork great care should be taken that the boxes are plumb and that they are set true to line, without winds or twists. Otherwise the concrete will not only be of bad appearance but must often be removed and corrected at great expense. All centering and supports must be properly braced and cross-braced in two directions, especially to resist storms and high winds. Forms and centering must be strong enough to easily carry the dead weight of construction as a liquid and the load due to placing, without any deflection. All joints must be fairly tight, so as to prevent leakage of the liquid mass, which would cause honey-combing in the concrete. The arrangement of forms and centering should be such that the slab centering and sides of beams and column forms, may be removed first, and then allow the bottoms of beams and girders to be supported for a longer time.

Place beveled strips in the form boxes to finish column and beam edges.

The foot of each column box must remain open on one side for joining and adjusting the reinforcement, but especially for inspecting and cleaning out just before pouring the concrete. Saw dust and other foreign matter can be removed from the steel and the column sides with a hose. in fact all the falsework should be thoroughly cleaned before any concrete is placed on same. It is of vital importance that the above mentioned opening remains open until the first wheelbarrow with rich concrete or mortar is waiting above. Be especially careful that no wooden blocks, shavings, saw dust, etc., remain in the form when the concrete is placed.

Where the centering posts come on soft ground, or a tile floor, their load should be distributed by means of scantlings or short piles; otherwise the supports are sure to be pushed into the ground, causing a sag and possibly cracks in beams and floor slabs. All uprights should be set upon a double set of wedges cut from 4x4-in. scantling.

In building forms and centering, remember that the cost of timber is a large item of the total cost. With a little ingenuity and forethought this work can be most always arranged so that repeated use is made of each piece of timber.

Wedges and wire ties are most convenient in tightening up false work and removing it again afterwards without shock or vibration.

After the falsework is once placed it should be protected against severe temperature changes and against rain or snow. If it is necessary to leave the form-work empty for any length of time, then, before pouring the concrete, it should be gone over again carefully, the shrinkage joints repaired and the bracing and supports tightened up. In warm weather wet the forms before placing concrete, otherwise the lumber will absorb the water in the concrete and cause honeycombing.

Pine or spruce is far superior to hemlock for falsework. Hemlock when exposed to the weather becomes absolutely unreliable. For form boxes of columns or beams 2-in. timber is recommended; for floor slabs 1-in. boards on 2x8-in. joists spaced 16 to 24 in. apart, according to thickness of slab; for posts 4x4-in., spaced from 3 to 8 ft. apart, according to the height and the dimensions of beams and slabs; for bracing and cross-bracing, 2x4-in.

The skillful superintendent or foreman may be recognized by the scarcity of nails he uses. Column boxes should be securely clamped and beam boxes so framed that the floor joists practically hold the sides without nailing. If the removal of centering necessitates the use of the long prying crowbar with three laborers at its end, the foreman should be fired.

Reinforcing Steel.—As steel is received it should be checked, assorted and stored in such a manner that those portions needed first may be reached without disturbing the remainder. In large work, a man should be appointed whose sole duty is to look after the receiving, checking and storage of steel. All steel must be free from loose scales, but a thin film of rust will not be objectionable. Bars covered with loose or scaly rust must be cleaned with a stiff wire brush. Bars should be free from oil or paint, as either will lessen the adhesion of the concrete.

Steel should be properly braced, supported and otherwise held in position so that the placing of the concrete will not change it. The inspector must see that the correct number and size of reinforcing bars and anchors are used and that they are spaced and placed strictly according to plans and working drawings. This is of vital importance and should be looked after with the utmost care and checked over personally and finally just before pouring the concrete.

All protruding bars from piers, columns, beams and slabs, to which other bars are to be spliced and which will be exposed to the action of the weather for an indefinite period, must be protected from rusting by a coat of thin, neat cement grout.

All ordinary bending will be done cold, but it is very important, especially in bending the large bars, that the bending force be applied gradually and evenly and not with a jerk. A jerky action is likely to snap or crack the best steel.

Placing Concrete.—All forms must be absolutely clean and free from shavings or foreign matter before any concrete is placed. All concrete must be deposited in forms within ten minutes after leaving mixer. Before commencing to pour concrete, the reinforcement for the entire floor should be directly at hand with that for the columns below all in place. The placing of steel can then be carried on with the concreting but kept just a little in advance. If a tank or hopper is used for receiving the mixed concrete, great care must be taken to see that the hopper discharges uniformly and that mixed concrete does not accumulate and lie in the tank until it has set.

When concreting is once commenced it should be carried on rigorously to completion, if possible. If concreting must be stopped before the entire portion is completed, then the place for stopping should be determined upon by either one of the following two methods, although a great difference of opinion among experts exists as to this point.

Method I, for Stopping Beams and Girders: Stop concrete at the center of the beam with a vertical plane at right angles to the direction of the beam. For Stopping Slabs: Stop the concrete at the middle of the span, making the plane perpendicular, and at right angles to the direction of the span.

Method 2, for Beams and Girders: Stop the concreting in beams and girders directly over the center of the column, making a vertical joint and allowing one-half the column to become the bearing surface for the future adjoining beam. For Slabs: Break the concrete directly over the centers of the beam, making a vertical joint and allowing room for the future adjoining slab.

In either of the above mentioned methods and in every case there must be installed a sufficient number of continuity bars to tie the beam or slab to the opposite side. If there is no beam coming directly opposite the finished beam it should be connected well with the future opposite slab with steel. In no case shall work be terminated in beams or floor slabs where future shearing action will be great, as near the ends or directly under the concentrated load.

When concreting is in progress have the man who is stationed at the hopper instructed to constantly inspect the general appearance of the mixed concrete as it is poured into the wheelbarrows. He must see that it is of the proper consistency and fluidity, that no foreign substances, such as wooden blocks, chips, etc., have found their way into the mixture. Also he must be able to judge by the appearance as to the proper proportions having been used.

All beams and slabs must be filled to the top surface in one continuous operation, that is from bottom of beam to top of floor construction. Also the concrete on top of tile floor construction must be placed at same time as concrete joists. Unless this is done the floor will be greatly weakened, and might have to be removed at great expense.

Spading and joggling the sides of girders, beams and joists is necessary to obtain nice appearing surfaces.

The greatest caution and vigilance must be exercised in filling columns. To start with, it is not sufficient to inspect and clean out the foot of the column box just before pouring, but look through it while open and lighted below, and assure yourself that no piece of wood or tile has fallen in and wedged somewhere. Columns should be filled six to eight hours ahead of beams. This is important.

It is recommended and considered excellent practice to fill the lower two or three feet of the column with 1:1 cement mortar, but if this is done or not done, it is absolutely necessary to expel bubbles of air by constantly puddling or joggling the concrete with a rod, wedge-shaped at the bottom, and heavy enough to sink the concrete with ease.

In columns greater in height than 12 ft. the entire column should not be poured from the top; pour about one-half in such case from an intermediate pocket. Constant puddling, however, is equally necessary in this case.

The pouring of a column must be a continuous operation to the bottom of the beam or girder.

Particular attention is called to the fact that concrete, after it has begun to set, must not be disturbed. If walked on or wheeled over during the time of setting, the set will be incomplete or may be entirely destroyed. Workmen are likely to pay little attention to this and constant watching on the part of the inspector is necessary to guard against it.

The concrete foreman must mark in ink upon the plans the date when each part of the work is concreted. This must be attended to every time concreting is done, and it must not be put off until some convenient time, and then filled in from memory.

A sample block of concrete should be made from each day's work. This sample should be poured into a box about 6x6x6 in., and the box should be dated. This will serve as a guide to determine the condition of the concrete before centering is removed.

Removal of Forms.—The falsework should be removed with great caution and without jarring the structure or throwing heavy forms upon the floor. Remember that even a moderate force or weight applied to the structure with a shock may cause destructive results. The practice of ramming down the posts and thus letting everything crash to the floor must not be tolerated. Three or four workmen should be set aside and trained for the removal of all falsework. The importance and dangers attending the work should be thoroughly impressed upon them, so that carelessness on their part would be classed as positive criminal negligence, subjecting them to probable imprisonment. Care in removing falsework will reveal any weak spots that may exist and which may then be repaired without any damage. Care should be taken that there is no great load on the floor at time centering is removed.

The following procedure of removing falsework is absolutely essential, it being assumed that the weather has been most favorable for the setting of concrete, that is warm and dry. In cool, damp weather it should be left in place much longer. Before undertaking to remove any falsework, the superintendent should personally satisfy himself as to the condition of the concrete. It should not only show a sufficient degree of hardness but should ring when struck with a hammer.

At the end of not less than seven days remove the sides of the column boxes so that the columns may be thoroughly exposed on all sides and their soundness approved. The airing of concrete assists the time of setting to a remarkable degree and should always be encouraged.

At the end of not less than two weeks loosen lightly the wedges from posts supporting floor slabs, allowing all posts to lower away from the overhead floor about 1 or 2 in. An examination should then be made of the work and the falsework should be left in this condition for at least 24 hours. Then gradually remove the shores, joists and sheathing supporting floor slabs.

Remove sides of beams and girders, allowing the bottoms to remain supported. This is important.

Temporary shores should be installed under the floor slab immediately after the original falsework is removed. These temporary shores should be left in place for at least a week. The quantity of lumber tied up in this manner is not very considerable, and the proper aging and hardening of the concrete is very much helped by the exposure to the air. After a period of one week, the temporary shores can be altogether removed; in case the newly made floor is not to be loaded with heavy materials. If it is liable to loading of any consequence the temporary shores should be left in place so long as such a possibility exists.

Shores should not be removed from under side of beams in less than three weeks.

Removal of forms and centering should never be started until the concrete is thoroughly set, and has aged to give it sufficient strength to carry its own weight, besides the live load which is likely to come on the work during the course of construction. In fairly warm weather this may be about ten days.

Cement Finish.—Do not attempt to put cement finish on top of floor slabs which have been previously concreted if the finish is less than 2½ in. in thickness, as it will not properly adhere to the body of the concrete. If an inch finish is specified on the floor, the finishing must be done at the time of laying the concrete, in order to have it adhere. Where the finish is put on after the floor slab has been constructed, the greatest care must be taken in cleaning the surface of the floor of all foreign matter and dirt, and the clean surface must be thoroughly grouted, in order to obtain the best possible cohesion.

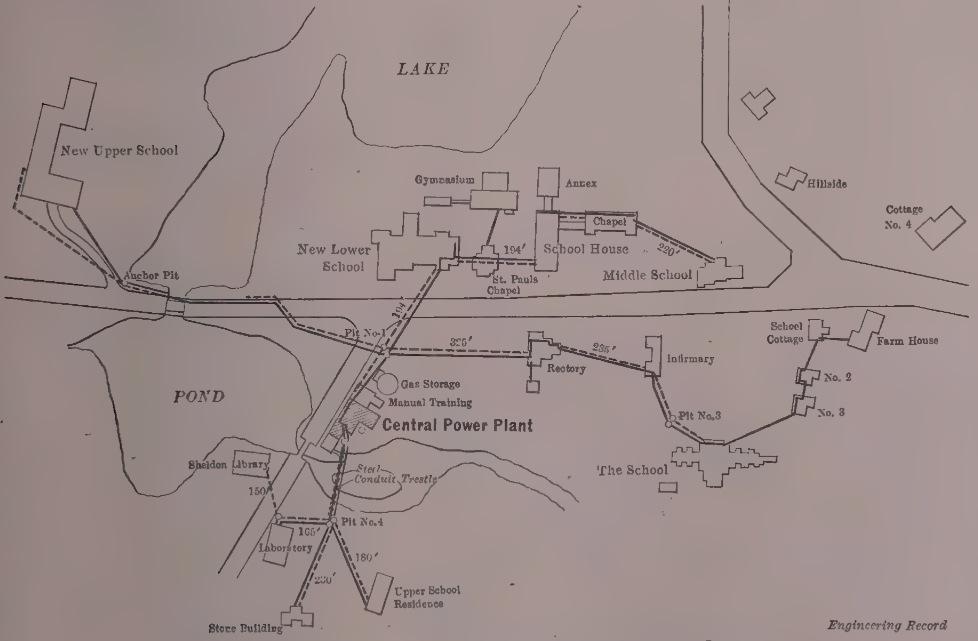
A kind of neat cement (without any sand) will aid in connecting the finish with the main concrete.

Finish should never be less rich than 1:2 and preferably 1:1. A coarse gritty sand is best; a fine round sand is very bad.

The Central Power Plant at St. Paul's School, Concord, N. H.

St. Paul's School at Concord, N. H., is a noted preparatory school which has an attendance of over 400 pupils. It is located some two miles from the city on grounds of 2,000 acres having a small lake, and has some 25 buildings that require heating and lighting. The buildings had formerly been heated by independent plants and lighted by gas, but with the recent growth of the institution, it became desirable to concentrate the service in a large centrally-located plant with more economical equipment. Accordingly a new power plant has recently been completed, which includes a steam plant, electrical generating apparatus and a water power auxiliary for lighting.

A fortunate arrangement of the grounds permitted a nearly central location for the plant with respect to the consumption of steam and power by the buildings. In a depression beside a branch driveway were located a manual training building, repair shops and small buildings for housing a water power lighting plant and fire fighting apparatus, the view of which was cut off from the driveway by a 10-ft. brick wall about 90 ft. in length. Advantage was taken of this in locating the plant in the 90-ft. space between the manual training buildings and the water power building adjacent to the bridge, and at a level so depressed that a two-story building was possible, housing the power plant on the main floor and new shops of the carpenter and repair department on the second floor, with the building still not in evidence above the brick wall. The ground level at the rear of the plant is some 15 ft. below that of the adjacent driveway, which forms the embankment, damming the pond and rendering a considerable fall of the water available for power development.



Plan of Grounds of St. Paul's School, Showing Conduits.

Power Station.—The 82x45-ft. power house is of brick, and has two stories, the lower having a clear headroom in the boiler room of 16 ft., while the upper floor, which is devoted to the carpenter and tin shops of the school's repair department, has 9 ft. headroom. It is built against the former brick retaining wall on the driveway, which was, however, raised 4 to 6½ ft. The floor of the boiler room is depressed 13½ ft. below the grade of the drive except at the rear next to the wall, which portion is 18 in. higher, while the engine room floor is 9½ ft. below the drive. The boiler room and shop floors are concrete. The concrete slab of the shop floors is 6 in. thick, reinforced for a load of 300 lb. over the boiler room and 175 lb. over the engine and pump room. Between the boiler room and the manual training building is a passage 10 ft. wide, one story in height, which extends to the rear and connects with a 30x43-ft. extension for fuel storage. The entire roof of this section is of reinforced concrete designed for loads of 350 lb., so that coal wagons may be driven over it to discharge coal directly into the pocket below.

There are four 150-h.-p. boilers of the horizontal return tubular type in a single battery with the Sidney Smith setting. They have shells 19½ ft. long and 6 ft. in diameter and each contains 120 3-in. tubes 18 ft. in length. They are designed for a working pressure of 150 lb., although the plant will be operated at 80 lb. The settings are fitted with Star rocking grates for hand firing, the grates being set at a distance of 27 in. below the boiler. A run-of-mine grade of bituminous coal is used. The boilers were supplied by the D. M. Dillon Steam Boiler Works, Fitchburg, Mass.

A fuel storage capacity of nearly 700 tons has been provided, the total floor area of both the main coal pocket and the 10-ft. passage at the side of the boiler room, amounting to nearly 1,800 sq. ft., while the headroom in the pocket is for the greater part 14 ft. There are nine coal holes 24 in. in diameter provided in the concrete roof of the pocket and three over the side passage. The roof of the pocket is elevated but a few inches above the level of the driveway, which thus entirely obviates handling in placing the fuel in the storage. The coal is wheeled to the firing floor, a set of platform scales in the boiler room floor near the coal pocket door facilitating the keeping of fuel records.

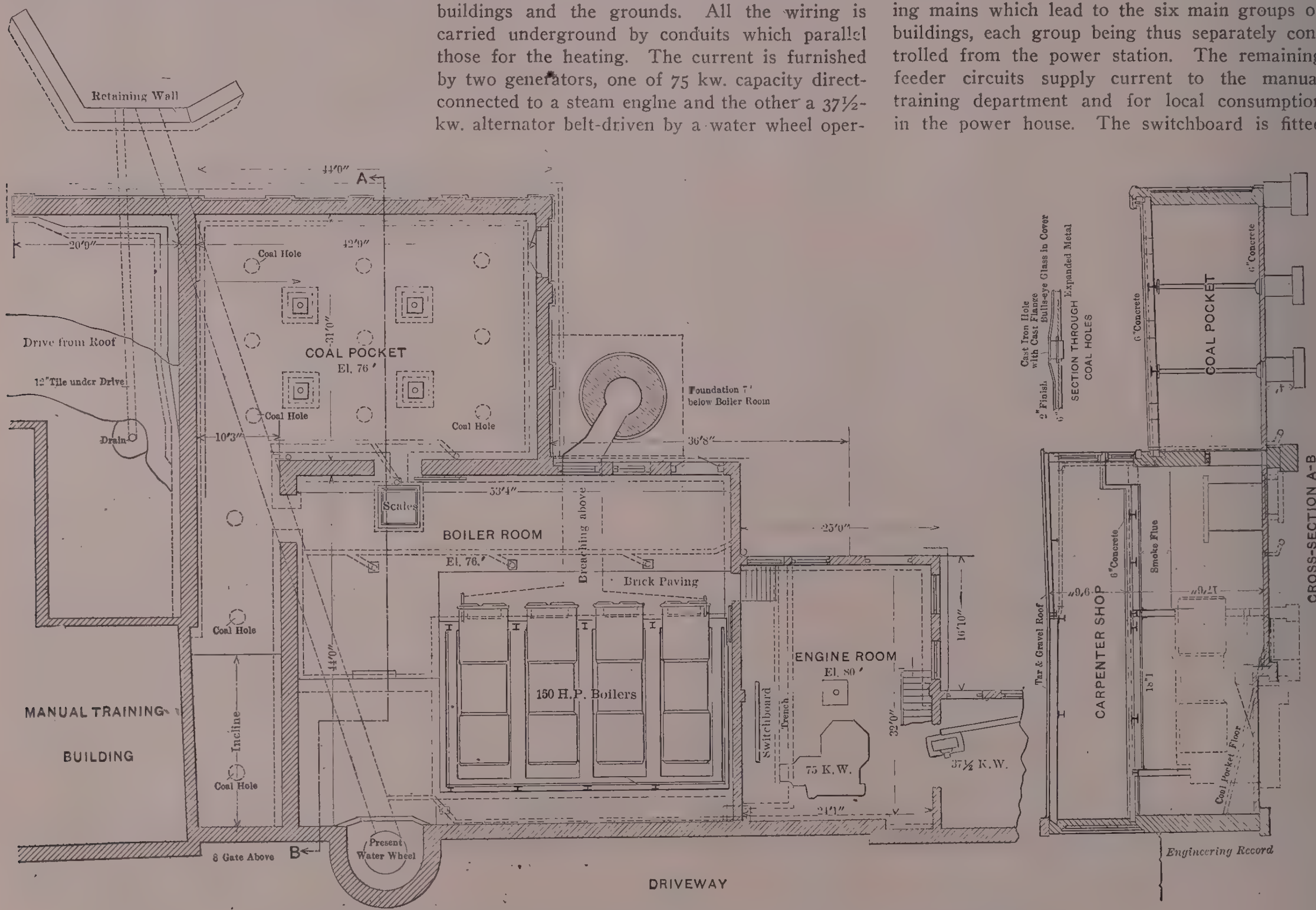
The products of combustion are removed through 12x60-in. up-takes at the front of the boiler shells which connect into a 48x60-in. breaching on the boiler room ceiling; the latter is extended through the rear wall of the boiler room to a brick stack which rises 125 ft. above the boiler room floor level. The stack has an internal diameter of 4½ ft. and is 11 ft. 3 in. in outside diameter at the base tapering to 6¼ ft. outside at the top. The chimney has a lining to a point 100 ft. above the base, with continuous air space between it and the outer shell, and the lining has an inner facing of firebrick from below the smoke breaching opening to a point 25 ft. above.

The boilers are fed by two 6x4x6-in. Warren brass-fitted duplex pumps in the engine room at the rear. They are connected so as to return condensation from the heating system and also from the high and low-pressure drip tanks, and have make-up connections to the water service system and to the adjoining pond. The feed line consists of a 3-in. brass main which extends to the boiler fronts, with a by-passed loop to a feed-water heater at the rear of the boiler settings. The feed may thus be by-passed from the pumps directly to the boilers, although it will normally be passed through the heater, which is a 20x84-in. closed tube heater, connected inductively to the 6-in. exhaust line of the power plant. The boiler feed connections consist of 1½-in. pipe branches from the feed main which deliver through the heating coils of the Sidney Smith settings and thence enter through the front heads of the boilers, 3 in. above the upper row of tubes, and extend within to the rear and down to an outlet near the bottom of the shell. The blow-off connections consist of 2½-in. outlets into the bottom of each shell 12 in. from the rear head, which are connected through plug and gate valves to a 3-in. blow-off header at the rear of the boilers. This header is extended a short distance to one side of the settings and thence through an opening in the floor to an adjoining tail-race from a small water wheel, which utilizes the fall of water from the pond to drive the machinery of the manual training department and repair shop.

The high-pressure steam piping has a 12-in. header over the boilers, joined to the delivery connections through an 8-in. loop at the rear of the room, forming, in effect, a ring header. This is supplemented by a 4-in. auxiliary header at the rear, which is cross-connected into the main header and also has a 1-in. branch connection to supply the feed pumps in the engine room. There are two 6-in. nozzles to each boiler shell; the main header is connected to the forward nozzles through 5-in. branches with long radius bends and the auxiliary header to the rear nozzles, on which the safety valves are mounted. From the main ring header there are two delivery connections, one a 7-in. line at the engine room from which a 5-in. branch supplies a 75-kw. generating unit. The line continues thence as a 5-in. main to a pressure reducing valve at the rear of the building which feeds into a 6-in. low-pressure underground heating main. At the opposite end of the ring header two lines are extended to the underground distribution system, one a 5-in. high-pressure main and the other a 6-in. line which connects through a reducing valve to a 10-in. low-pressure heating main. Both of the reducing valves are by-passed and on the low-pressure sides have connections with the exhaust steam system of the plant. The latter consists of a 6-in. line from the generating unit with 1¼-in. branch from the feed pumps, which is passed through a grease extractor and extended to the 6-in. heating main at the rear and the 10-in. heating main at the front. Both the high and low-pressure headers and mains are provided with drip systems, connected to traps that return the condensation into the feed pump suction lines.

Heating System.—Steam for heating is distributed through mains laid with the condensation return lines in sectional conduit with asbestos sponge filling. There are two general divisions of mains, as indicated in the plan of the college grounds. The heating mains to the buildings are all operated with exhaust or low-pressure steam, using a pressure not exceeding 4 lb., with the exception of the new upper school, which is at a considerable distance from the power house and is operated under a pressure of 40 lb. There are in addition a 2½-in. and two 1½-in. high-pressure mains which deliver steam at 40 lb. pressure to two groups of buildings for cooking purposes.

The heating distribution mains consist of a 10-in. low-pressure and a 5-in. high-pressure line from the power house to a manhole near the central drive, from which a 5-in. high-pressure supply is extended to the new upper school, while the low-pressure supply main is divided into an 8-in. line to the lower and middle schools and a 6-in. line to the rectory, infirmary and cottages. These lines are all paralleled by drip lines, which have frequent connections to the mains, and by return lines. The drip lines are for the greater part of 1¼-in. joining in a 1½-in. main drip from the manhole to condensation tanks in the engine room. The return lines have in general a cross-section about one-fourth of that of the supply. The main supplying the group of buildings on the opposite side of the pond is a 6-in. line, which branches from a manhole into a 5-in. supply to the laboratory, a 3½-in. supply to the stone building and a 2½-in. supply to the upper school residence. The drip return lines from these buildings join a 1¼-in. drip returning to a trap in the engine room, while the return lines join into a 3-in. return to a condensation tank in the engine room.



Plan of Central Power Plant and Coal Storage Pocket, St. Paul's School.

The underground mains are laid in the Portland system of sectional conduit, supplied by the H. W. Johns-Manville Co., which consists of salt-glazed vitrified tile, filled with sponge asbestos for heat insulation. The tile sections are parted in halves longitudinally with rough edges to take cement. This permits laying the lower halves of the conduit first, then locating the piping and subsequently filling with the sponge asbestos and enclosing the whole with the upper halves. The piping within is supported on roller frames at 18-ft. intervals. The roller frames are mounted on and anchored in cement piers, which project down through special T-sections of the conduit provided for this purpose. At intervals in the conduits there are reducing T-sections with small branches carried up to ground level for inspection of the interior of the conduit and to permit refilling it with asbestos sponge. The openings into the basements of buildings are closed by cement shutters which may be easily removed when necessary for access to the piping.

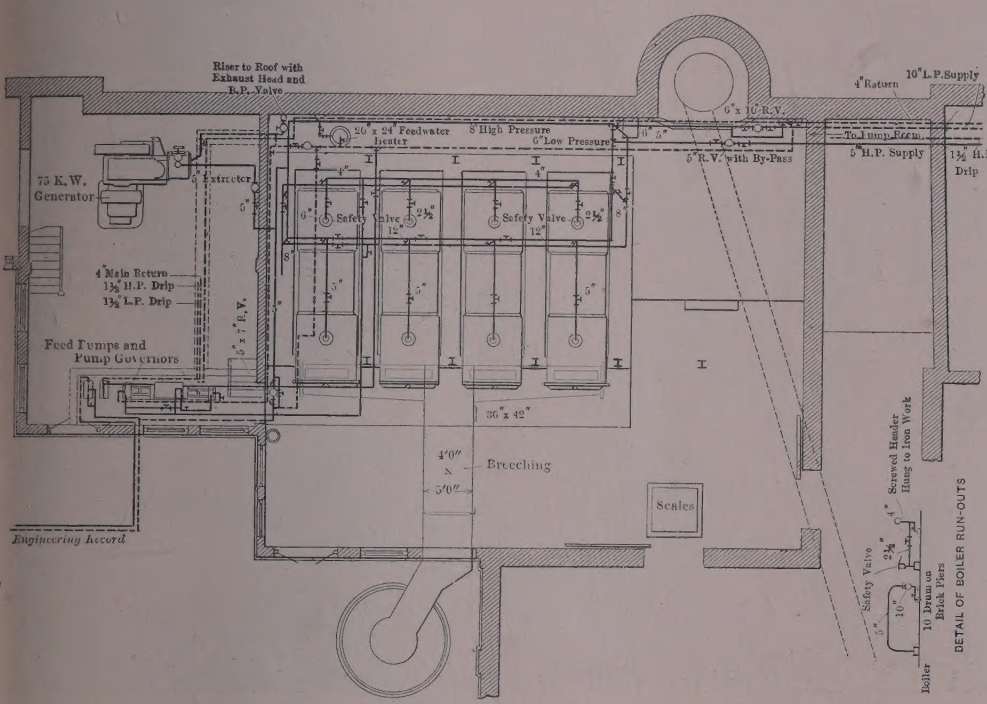
The pipes cross the pond in two places, one at the rear of the power plant and the other at the side of the bridge on the central drive near the new upper school. The mains are here enclosed in steel conduits carried across the streams at such an elevation as to prevent flooding in case of extreme high water. These conduits are strong metal boxes of 15-in. channels and ⅜-in. plates. The width of the boxes is 18 in. inside in one case and 20 in. in the other, and they are 36 and 105 ft. long respectively. Both conduits are supported by trestles. The pipes are supported in them by roller blocks 10 to 12 ft. apart.

Electrical Equipment.—Current is supplied from the central power plant on the 220-volt, two-wire alternating-current system for lighting both the buildings and the grounds. All the wiring is carried underground by conduits which parallel those for the heating. The current is furnished by two generators, one of 75 kw. capacity direct-connected to a steam engine and the other a 37½-kw. alternator belt-driven by a water wheel operated from the water power available from the dam. The engine is a 15½x14-in. Watertown simple horizontal engine, which operates at 277 r.p.m. The steam is supplied by a 5-in. branch from the high-pressure header in the adjacent boiler room, while the exhaust is piped through a 6-in. connection to both the steam heating main and atmospheric riser with back pressure valve, which is carried up to an exhaust head above the roof.

The engine-driven generator is a two-phase Westinghouse alternator wound for 220 volts, the distribution system being arranged on the two-wire system. It has a compound winding and a 5-kw. exciter is belted from the engine fly-wheel. The unit is controlled from a panel of the switchboard which contains a voltmeter, an ammeter for either phase, a field current ammeter, a voltmeter switch, a ground detector switch, rheostats and switches. The 37½-kw. generator is a Westinghouse belt-driven, two-phase alternator. It has a 2-kw. belted exciter and is controlled from a panel on the switchboard with equipment similar to that for the other machine. The water wheel is a 40-h.-p. Hunt vertical turbine which has been installed in the small building in place of the original smaller turbine which had been used to operate two small direct-current generators for lighting a part of the buildings. The new wheel runs under a head of 12 ft. and is regulated by a governor built by the Holyoke Machine Co.

The electrical distribution is controlled from a third panel of the switchboard, which contains twelve 100-amp., double-throw knife switches. The switchboard is provided with two sets of bus-bars, one for either generator, on either of which any of the feeder circuits may be thrown, so that either or both machines may supply any group of buildings without the necessity of operating in parallel. Six of the feeder circuits control lighting mains which lead to the six main groups of buildings, each group being thus separately controlled from the power station. The remaining feeder circuits supply current to the manual training department and for local consumption in the power house. The switchboard is fitted with Noark fuses in place of circuit-breakers and for the indicating instrument equipment Westinghouse voltmeters and ammeters are used.

For underground distribution duplex cables are used, insulated with varnished cambric and sheathed in lead, which are laid in vitrified tile conduit. The conduit is installed in four and six-duct sections in cement envelopes and connects with each group of buildings through junction pits. The cables are carried across the pond in iron pipe in both cases, which is supported on the trestles carrying the heating conduits. The lighting is, as above stated, accomplished for the greater part by incandescent lamps of varying candle-power, the 20-c.p. lamp predominating, although in a number of lecture rooms and halls the Nernst lamp is used. Of the latter there are 64 in all, with a total of 210 glowers, while the incandescent lighting gives a total connected load of 599 16-c.-p., 1033 20-c.-p. and 65 32-c.-p. lamps, the distribution of which is shown in the accompanying table. The Nernst lamps are operated at 220 volts, using 4 amp. per glower. There is in addition a small motor load, including in the new upper school a 3-h.-p. motor; in the upper school a 3, a 2 and a ½-h.-p. motor; in the manual training building a 3 and a ½-h.-p. motor; in the laboratory a ½-h.-p. motor; in the power house a 2-h.-p. motor, and in the boys' shop several motors amounting to 5 h.-p. in the aggregate.



Piping Connections, Central Power Plant, St. Paul's School.

Heating and Power Sebvice in St. Paul's School Buildings.

Building.	Heating Surface.	Lighting.
The School........	4,590 sq. ft.	307—20 c.p.
New Chapel	2,480 " "	
Old Chapel	940 " "	
School House......	2,200 " "	47 Nernst, 128 glowers.
School House Annex	1,550 " "	165—20 c.p. 20—32 c.p.
Gymnasium	2,000 " "	42—20 c.p. 45—32 c.p.
House No. 3.......	500 " "	
Stone Building.....	1,015 " "	59—20 c.p.
Rectory	2,080 " "	60—32 c.p. (proposed).
Infirmary	1,200 " "	80—32 c.p. (proposed).
Laboratory	980 " "	72 Nernst, 190 glowers.
Sheldon Library....	2,400 " "	240—20 c.p.
Middle School.....	1,260 " "	55—20 c.p. (proposed).
Lower School......	4,400 " "	220—20 c.p. 14 Nernst, 64 glowers.
Shops	1,600 " "	
House No. 2.......	375 " "	
School Cottage.....	600 " "	
Upper School......	610 " "	599—16 c.p. 3 Nernst, 18 glowers.
Farm House.......	500 " "	
New Upper School.	8,800 " "	
Total	40,080 sq. ft.	

The construction of the power plant and underground piping and electrical distribution systems was carried out by the authorities of the school by day work. C. L. Fellows & Co., Concord, N. H., were the contractors for the power house building. The Richard D. Kimball Co., engineers, Boston, Mass., were engineers for the entire work and supervised its installation.

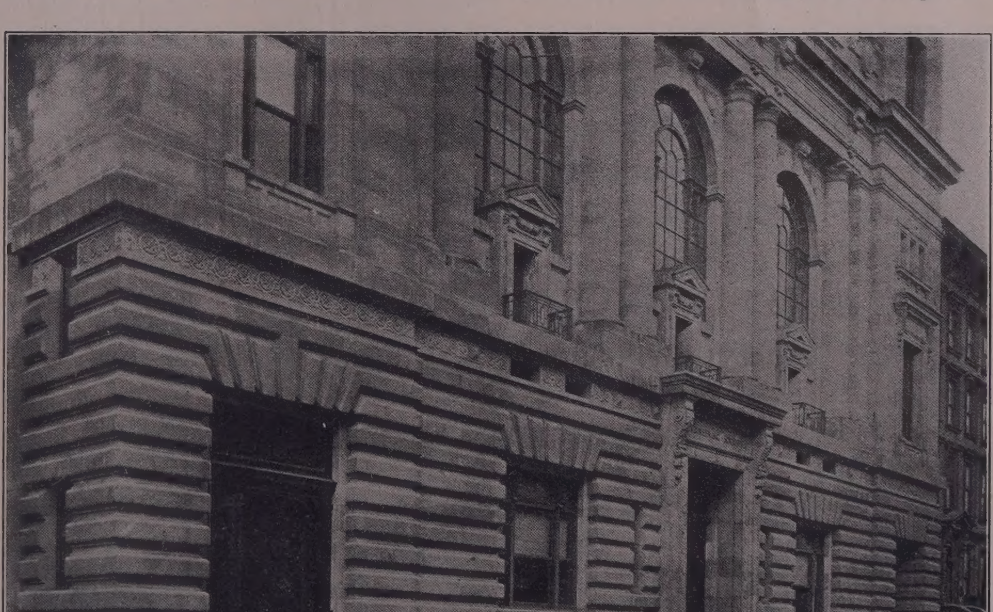
The Pennsylvania Terminal Work in New York is progressing rapidly. In Long Island City the southern tube of the four that are being driven under the Long Island R. R. property has reached the river shaft, and the tubes running toward Manhattan are out about 350 ft. under the water. The subaqueous tubes running from Manhattan eastward are more advanced, three of them being driven at present through Blackwell's Island. Most of the excavation for the terminal building has been completed and the foundations for the steelwork are being laid. The tunneling under Bergen Hill on the Jersey shore is progressing faster than ever.

The Engineering Societies Building, New York.

On April 16 the Engineering Societies Building on West Thirty-ninth St., just off Fifth Ave., will be formally dedicated, although it has been in use for some time. The history of the movement which led Mr. Carnegie to give the money needed for the structure does not require another review in this journal. The leading floor plans were printed on Dec. 16, 1905, and a description of the heating and ventilation plant appeared on Feb. 16. The building is controlled and its finances regulated by the United Engineering Society, incorporated for the purpose in 1904. The title to the land also rests in this body. The character of the society, its by-laws, etc., were given most careful thought by the societies, their legal counsel, the committee as a whole, and in particular by Dr. S. S. Wheeler, to whom the intricate matter was entrusted as chairman of a sub-committee. The first president of the United Engineering Society was Dr. A. R. Ledoux, who was succeeded by the present incumbent of the office, Mr. E. E. Olcott.

The frontage of the Engineering Societies Building on Thirty-ninth St. is 115 ft., and the depth is 90 ft. The property itself is 125 ft. front by 110 ft. depth. It is designed in the French style and rises 13½ stories above the sidewalk to a height of 218 ft. 6½ in. The exterior is built of limestone up to the auditorium floor, and of gray mottled brick and terra cotta above; the whole having a cheerful cream tint on all four sides. As the lower portion is devoted to auditoriums, the middle section to offices, and the upper part to the library, an effort has been made to accentuate these three separate parts of the building.

Access to the building is gained by the central entrance on the street level to the first floor, by the western side door leading to the elevators, and by the broad driveway which encircles it completely, so that carriages can enter by the eastern covered arch, set down their occupants at a side entrance and emerge by the western gate. There are three elevator riseways in the main elevator shaft, faced with an iron grill lined with wire glass. On each side of this shaft wide stairways rise to the sixth floor of the building, and one leads thence to the library floor. A freight elevator has been installed on the eastern side of the building, and a commodious service stairway on the north side rises the entire height of the edifice. At the first floor a rear door communicates across the ten-foot areaway, in the open, with the café of the Engineers' Club, and on the ninth floor a flying covered bridge connects with the breakfast room on the tenth floor of the club.



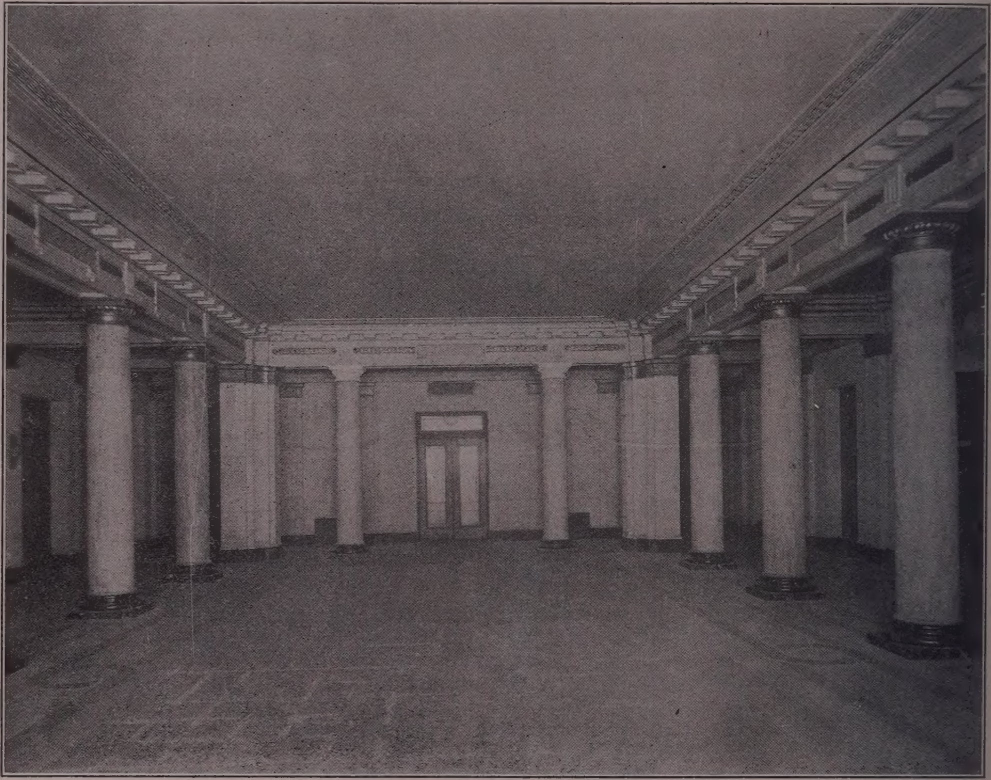
The Lower Facade of the Building.

The spacious first floor is laid with Tennessee marble tile, having a border in design of colored marble. The central court or main foyer is marked by twelve large columns of Swiss Cipolin marble. A short low flight of steps leads from the foyer to the elevators, and at will a metal grille is thrown across the steps so as to restrict or direct travel. Gold ornament is used sparingly for architectural accentuation, and the woodwork is in dark oak. Large chairs and lounges in red leather furnish the foyer and similar furniture is used in the writing-room, smoking-room, reception room and administration room, which also contains three telephone booths associated with the "private exchange" system. On the foyer walls, facing toward the main entrance, are two large bronze tablets, one bearing a relief portrait of Mr. Carnegie and the words of his second terse letter of gift of $1,500,000, and the other a statement to the effect that the land was given by members and friends of the three founder societies. On this floor also, at the rear, are receiving and shipping offices through which all freight and goods are handled. In time this floor will be graced with statuary, but even now it creates a most favorable impression as one enters the building.

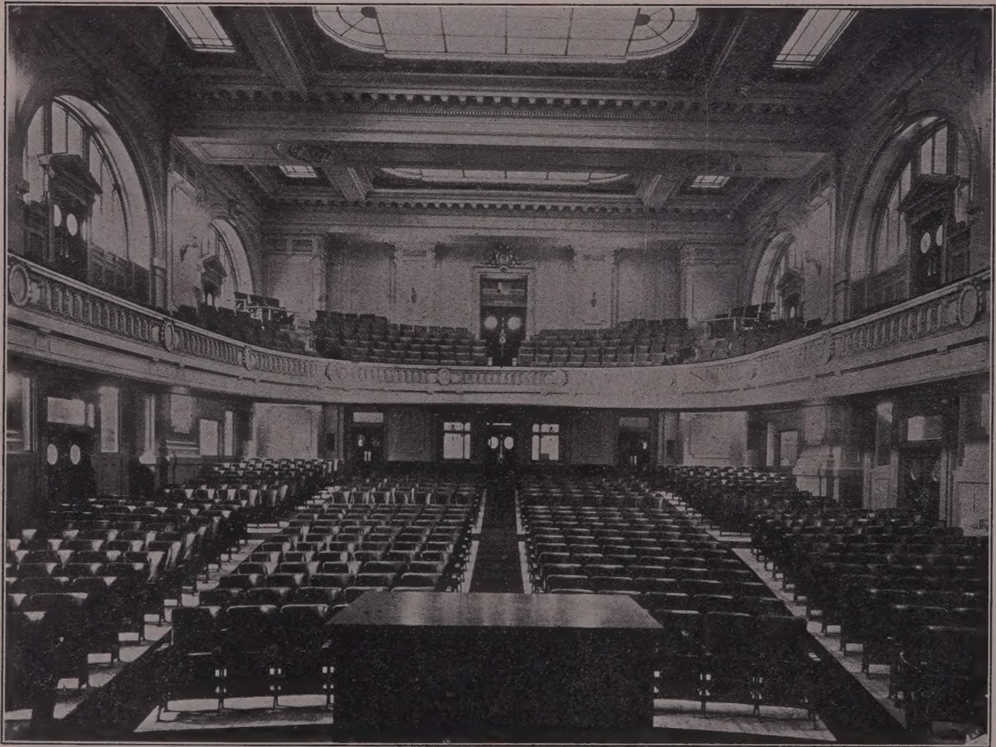
Immediately above the first floor is the coat room, laid out on a sectional plan so that several lines of persons may be accommodated at once on entering or leaving. Special toilet facilities are also provided on this floor, which virtually occupies the space that would otherwise be left blank by the slope of the main auditorium floor just above it.

The main auditorium extends up through two floors and with its gallery will seat about 1,000 persons. The requirements of this chamber were unusual and difficult of definition. It had to be arranged primarily for the general meeting of the societies, at which the speaking is from the floor as well as from the platform, and at which diagrams, illustrations or blackboard drawings are often employed. This is quite the opposite from the ordinary audience hall, where the stage is the starting point both for the seating arrangements and for the acoustic and optical necessities. Hence the platform is notably small for so large a hall, accommodating few persons, while any speaker in the audience is easily within range of observation by everybody.

On both the parterre and the gallery floors, at the sides, the auditorium is surrounded by corridors, rendering access to every point very easy, and permitting ready withdrawal for conversation, committees, etc. The corridors assist also in maintaining quiet within the hall. The platform has ante-rooms and is conveniently close to the freight elevator, for delivery of apparatus. There is also a fine stereopticon equipped with connections for moving pictures. The seats are fixed opera chairs in red leather with revolvable tops, and the aisles are laid with red carpet. The gallery front is bordered in red plush. Above the auditorium arch is a decorative cartouche bearing the badges of the three founder societies. There are side brackets for lighting, but the main illumination is effected indirectly through the glass ceiling, above which are incandescent lamps controlled from several panelboards. The elevators and stairs open directly upon the two floors of the auditorium which can thus be emptied very quickly in case of emergency. Practical tests of the chamber have already shown it to be a success in every respect of comfort and convenience.



View of Main Hall, Looking toward Entrance.



Main Auditorium as Seen from the Platform.

The Lecture Rooms.—The next two floors above the main auditorium are devoted entirely to lecture rooms of which there are no fewer than seven. Two spacious assembly rooms, 51 feet by 66 feet and 29 feet by 66 feet, occupy the larger part of the fifth floor in such a manner that they can be used independently, or one may be made auxiliary to the other. Two smaller rooms on this floor, 16 feet by 22 feet and 18 feet by 19 feet, can be also used separately or as annexes for reception or conversazione purposes, and provision is made with steam tables, etc., for the service necessary for luncheons or light refreshments. All these rooms are agreeably finished in soft light tints and have facilities for water, air, electric connections, etc., for demonstrations and experiments.

The sixth floor is also divided into lecture rooms, planned somewhat differently, and of smaller dimensions than those on the floor below. The dimensions are respectively 22 feet by 44 feet 6 inches; 30 feet by 46 feet 6 inches; 30 feet by 41 feet, and 20 feet by 28 feet. In this manner the building affords facilities to audiences of every size from 1,000 down to 100, while on occasion every room can be occupied by sections and subdivisions of an engineering or scientific meeting, with independence and without interference.

The Office Floors.—The seventh and eighth floors of the building have been reserved for the associate societies that have engineering or some department of science as their principal object. For these organizations the building affords office areas of varying size, from one room up, with the common facilities of the lecture rooms, library and other accessories. Among these societies may be enumerated the Society of Naval Architects and Marine Engineers, the Society of Heating and Ventilating Engineers, the National Electric Light Association, the Society of Chemical Engineers, the New York Electrical Society, the Association of Edison Illuminating Companies, the American Street and Interurban Railway Association.

Founder Societies' Floors.—Each of the three founder societies occupies a floor laid out in accordance with its own plans. The American Institute of Mining Engineers has the ninth floor, the American Institute of Electrical Engineers has the tenth floor and the American Society of Mechanical Engineers has the eleventh floor. These floors are all devoted to administrative and executive work, and the libraries of the three societies have been concentrated in the two top floors of the building.

The Library.—A crowning detail in the plan of the building has been the reservation of the twelfth and thirteenth floors for the libraries of the three founder societies and of such other collections of engineering literature as may be added. The twelfth floor below the library proper has been devoted to the book stacks, but at the present time the main library is also equipped with one tier of stacks, with provision for a gallery tier later. The stack room is partly equipped with stacks, and in the library a delivery desk, reading tables and chairs have been provided. The founder societies entertain the ambition of creating and maintaining the finest collection of engineering literature in the world, supplemented by the current periodicals, and all the patents relating to invention in the arts and sciences. Provision is being made for special research accommodation, working alcoves, photographic reproduction, drawing and similar library work. Commanding magnificent views of Greater New York and vicinity in every direction, the library is retired, quiet, free from noise and dust, an ideal haunt of the student and man of research; while open at all times to any reader. In view of the proximity of the New Public Library, the Engineering Societies Building with its unequalled collection of scientific and industrial data becomes at once a vital and important center of the highest value for the diffusion of useful knowledge, and the two libraries supplement each other.

Library, Looking Eastward from Elevator Entrance.

A bronze bust of Mr. Carnegie, executed especially for the building by Mrs. E. Cadwalader Guild, a well-known sculptor, from sittings, and presented by the present and past officers of the founder societies, stands at the eastern end of the library, facing toward the main entrance from the elevators.

Book Notes.

It is a pleasure to announce the publication in a separate volume entitled "The Value of Pure Water" of the interesting and valuable dissertation on the subject which was contributed by Mr. George C. Whipple to the "Biological Studies by the Pupils of William Thompson Sedgwick." This paper at once attracted a wide degree of attention which was fully deserved. One of the hardest things the sanitary engineer has to do is to convince those who hold the strings of public purses that impure water is very costly. As Mr. Whipple well says, the financial standard is certainly not the highest one for judging the quality of a water supply, for human life cannot be estimated in gold dollars and the odor of unsavory water to a thirsty man cannot be reckoned in dimes, but nevertheless the financial basis is a convincing one in urging needed improvements on reluctant public authorities. The book is in three sections. In the first the value of pure water is discussed and formulas are given for computing the effect of the sanitary quality of the water, the effect of its general attractiveness and the effect of its hardness on its value to the consumers. A large amount of related information from various sources is also brought together and analyzed in a most instructive manner. In the second part of the book Mr. Whipple gives a valuable discussion of what pure and wholesome water really is, and in the third part he explains the disadvantages of hard water. (New York, John Wiley & Sons, $1.00.)

A little manual of interest to railway engineers who have occasion to run in spiral curves and are not required to make their work of this sort conform to some set of regulations is the "Six-Chord Spiral" of Mr. J. R. Stephens. The two forms of spirals in general use are, first, the track parabola, in which the deflections from the point of spiral vary as the squares of the distances measured from the same point along the curve; and, second, the polychord spiral, in which the degree of curve increases with each chord, in arithmetical progression. The second form of spirals may be subdivided into three classes: first, those with deflections constant while the chord length and number of chords varies, like the Searles spiral; second, those with the chord length constant, while the deflections and number of chords vary; third, those with the number of chords constant, while the deflections and chord lengths vary. Of all these the author prefers the six-chord spiral of the last class, because it has an extremely simple relation to the one-chord spiral or terminal arc of half the degree of the main curve and on account of its close approximation to the track parabola. The author gives full directions for the field work and discusses in detail various methods of spiraling old track. The advantages claimed for the six-chord spiral are the following: 1, It is perfectly flexible and always fits. 2. No special tables whatever are required for general use. 3. The spiral is adapted to the curve, and not the curve to the spiral of fixed offset or length. 4. Odd curves are as readily fitted as even ones, which saves time and trouble in spiraling old track. 5. Intermediate transit points may be set at any plus, and do not lead to complex deflection calculations. 6. The method is quickly grasped, memorized and applied by transitmen with no previous knowledge of spirals; on location it is not even necessary to run in the six-chord, a terminal curve of half the degree of the main curve and giving the same length as the spiral line being substituted. 7. It is perfectly interchangeable with the cubic parabola, the two being, within the common limits of spiraling, practically identical. (New York, Engineering News Publishing Co., $1 in boards and $1.25 in cloth.)

An unusually interesting series of papers by Mr. W. H. Thorpe, which was printed in "Engineering" last year, has been republished under the title of the "Anatomy of Bridgework." No other book like it has probably ever appeared; it is hardly an "anatomy," but rather a series of "clinics," for it is a discussion of lessons to be drawn from a large number of detailed examinations of metal and masonry bridges which have developed defects of a more or less serious nature under load and from other adverse influences. Much may be learned from the study of defects and failures, even though they be of such a character that no experienced designer would now furnish like examples. Most of the examples cited are bridges or parts of bridges of quite small size, which makes the book valuable to a wide circle of readers who have nothing to do with long-span structures. Girder bearings are first taken up, and a number of examples of trouble with masonry supports caused by defects in such details are given. Troubles that have occurred in plate and lattice girders are next explained, and afterward there is a chapter on bridge floors, which are a source of many annoyances in maintenance. Bracing is considered in the following chapter, and the notes refer to towers and piers as well as to bridges. The next chapter, on riveting, contains some very interesting notes and pictures of rivets from old structures. The sixth chapter contains a discussion of some interesting examples of high stresses in bridges, including one built of steel in 1861, probably one of the first steel bridges ever erected. The subject of deformation and deflection occupies two chapters, and the author then takes up decay and painting. Some valuable data are given concerning the effect of salt water on cast-iron piles, a subject related to the deterioration of cast-iron mains by sea water, which has attracted considerable attention among waterworks' superintendents. Up to the close of this chapter, the book has been devoted particularly to defects of various kinds, but in the next two chapters the author describes the steps to be taken in examining a bridge and explains methods of repairing and strengthening such structures. After that there are separate chapters on cast-iron, timber and masonry bridges, and a discussion of the life of bridges. Finally there is an explanation of methods of reconstructing and widening these structures. The book as a whole is unusually interesting and contains a large amount of information of a class which is rarely printed, although of much value. A great merit of the book is the fact that every example described comes under the author's personal observation. (New York, Spon & Chamberlain, $2.50.)

The number of gas and gasoline engines in use is increasing so rapidly, and they are so often in charge of people not well acquainted with their operation and troubles, that there is a marked demand for a book containing information of a "practical" nature which will help those who have to manage such motors. To satisfy this demand the publishers of the "Gas Engine" have compiled a small 274-page book entitled "Questions and Answers," from the correspondence columns of that journal. These are not the fake questions of the "catechism" type of book, but real inquiries from men who needed the information. While it has been impracticable to classify the questions completely, they are arranged approximately under theory of design, mechanical design, marine design, automobile questions, gas producer questions, general questions and trouble inquiries. There is a large amount of useful information in the book, which is rendered readily available by a good index. (Cincinnati, Gas Engine Publishing Co., $1.50.)

Letters to the Editor.

Drawings for Field Use.

Sir: Your comments on drawings for field use in your issue of March 23 are particularly timely. As an engineer who has an opportunity each year to visit many different construction projects, it has often occurred to me that the usual method of furnishing large blueprints of plans to field offices is entirely wrong. Such prints are not only difficult to handle in the field, but they are entirely out of place in the shacks generally provided for field offices.

In connection with what you have said regarding the photographic reproduction of large-size drawings to a small scale for use in the field, it may be of interest to call attention to what has been done along those lines by the Bureau of Filtration of Pittsburg, under the direction of Mr. Morris Knowles, chief engineer. The work that is being done by this bureau involves the expenditure of $7,500,000 for a water filtration plant, the whole project being divided into ten contracts. The nature of this work requires a large number of detail drawings which are used almost constantly in the field. The original drawings were all made on the usual full-size sheets—26x42 in., I believe—and were then photographed on 8x10-in. negatives from which blueprints were made for distribution to the assistant engineers and to the contractor's representatives.

The original drawings were all made by the draftsmen of the regular office force of the bureau, who were furnished only brief instructions as to the size of lettering, the necessity of avoiding concentrated line or symbol work, such as is frequently unnecessarily used to represent earth, concrete and so forth. With no previous experience in such work these men produced drawings that were perfectly legible when reduced, the reproductions having, in fact, a better appearance in most cases than the originals. The blueprints from the small negatives are bound in folding leather pocketbooks, which protect and preserve the prints, and can be placed in an inside coat pocket. This system, I was given to understand, has proved very satisfactory among those who use the small prints in the field. At the same time it enables a considerable saving to be made in blueprint paper over the amount that would be required if large prints were used. Whether this saving would balance the cost of the small negative, I do not know, but the convenience of the prints from the latter is so great as to render insignificant whatever slight excess cost may exist.

Yours truly, Engineer.
Chicago, March 30.

Candle-Power Rating and Expert Testimony.

Sir: The arbitrators in the case of Colorado Springs v. the Pikes Peak Hydro-Electric Co. (see Eng. Record, March 16, page 344), have made their award and made their report, although not so soon as was anticipated. The city made essentially two claims, both based upon the fact that the lights furnished by the company to the city were less than 2,000 standard candle-power, which was mentioned in the ordinance governing the street lighting. They claimed, therefore, a reduction in all bills, which thus amounted to a refund on bills that had been paid and a reduction on bills that had not been paid.

The arbitrators were agreed that the 2,000-c.-p. lamp was a trade term and did not mean at the time of the contract 2,000 actual candle-power; also that although a change had been made in lights, which all agreed fell below an equivalent, there were some compensating advantages. The difficulty was to obtain a basis of comparison which should recognize the situation and be just to both parties.

The city had permitted the service from the lamps to continue for a number of months without protest. It did not appear that there had been bad faith on the side of either party, and therefore during that time it was considered that the responsibility was equally divided between the two parties. The award, therefore, took into account the difference between the light as furnished and the light that could reasonably be expected to be furnished, but considered this difference to be assumed by both parties prior to the time when protest was made.

In addition it was found that the service furnished by the company had not been kept up to what they could and should be expected to give. The amount of this deficiency was determined from the station records as closely as the evidence would permit. The station had records of the output of wattage per month and the average wattage per lamp. During one month every lamp in the city had also been tested, and this gave a means of obtaining the unknown losses in the circuits, which was used as a correction of the station records for other months. This was the only evidence of the kind that was sufficient to use as a basis for comparison. The wattage thus determined at the different lamps was then translated into candle-power from tests presented in evidence by Prof. Matthews, and this gave the means of estimating the deficiency in the candle-power of the lamps as they actually were used and the lamps at their normal condition.

The question which you assumed in your editorial (Eng. Record, March 16) was not specially under consideration; that is, whether wattage should be taken as a measure or not. Practically it amounted to the determination of candle-power by the use of wattage, which latter is a practicable means of measure while the former is not. As a matter of fact the increase or decrease of candle-power was not in direct ratio to the increase or decrease of wattage. A considerable difficulty was found in reaching a satisfactory basis of comparison of the lamp which has been used and the lamp which was in service at the time of making the contract. The character of light was somewhat different, and, as above stated, there were some compensating advantages in the present lamp, although it was not considered as equivalent by any of the experts.

Taking all things into consideration, which involves a good many minor questions, the arbitrators finally reached the conclusion that 20 per cent. would be a fair deduction for the difference in standards in this case. This was a fair conclusion from the evidence, although in this, as in the case of a number of other points, the evidence was rather meagre on some of the definite points which became important to the arbitrators in attempting to determine the numerical ratio. Assuming the distribution of responsibility, as above mentioned, between the city and the company for a part of the period, a difference of 10 per cent. was used for that period, while 20 per cent. was considered to be the normal difference in standards. With the additional allowance for the failure to keep the 6.6-amp. lamp to the normal wattage of 430, the deduction amounted to considerably more except for the few months the current had been boosted. This had been during the months of the present winter, and in that case a corresponding credit was given for the extra candle-power.

As a result of the whole considerations, the actual allowance to the city on the bills amounting to $30,794.69 amounted to $6,668.55, with an additional amount for interest due the city amounting to $212.12, and the fees provided by statute for arbitrators, which is made a part of the award and amounts under the statutes to $243.

From observation of the development of such a case and the conduct of lawyers in technical matters with which they are not familiar, I am decidedly of the opinion that a good expert with some knowledge of law, especially the law of evidence, would be a far better man, both for his client and the development of the facts, than the attorney with the knowledge of law and very little knowledge of the technicalities. That is especially true when before a board such as this, where the technical law points are of comparatively little consequence. The attorneys were pretty well prepared, but nevertheless were much at the mercy of things as they developed and were so much in control of the case that their technical advisers were not in touch with the general plan and, while advising, were not controlling the development. I can see if the expert became partisan that he might waste more time on unimportant details unless controlled by the court, but as a whole it would be a considerable improvement. The experts on both sides were of high enough character so that they were not sensibly partisan and did not attempt to distort facts, which experts are sometimes disposed to do; in fact, I think there is quite a broad distinction which ought to be made between experts' opinion and experts' facts. The latter case is where an expert is of most value and of most credit to himself. In the former case the skill of an attorney in framing a question which shall avoid an unfavorable answer or which may have a double meaning is often to blame for the disrepute of the experts, especially when the opposition is not able to frame a correspondingly skilful question of the other character.

Sincerely yours, L. G. Carpenter.
New York, March 31.

An Apprentice Course for 3,000 boys, it is reported, will be established by Mr. Charles M. Schwab at the Bethlehem Steel Works.